National Park Service
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Evaluation of the Sensitivity of Inventory and Monitoring National Parks to Acidification Effects from Atmospheric Sulfur and Nitrogen Deposition

Main Report

Natural Resource Report NPS/NRPC/ARD/NRR—2011/349

ON THE COVER
Some ecosystems and vegetation types, such as remote high-elevation lakes, sugar maple trees, headwater streams, and red spruce trees, are sensitive to the effects of acidification from atmospheric nitrogen and sulfur deposition.
Photograph by: National Park Service

Evaluation of the Sensitivity of Inventory and Monitoring National Parks to Acidification Effects from Atmospheric Sulfur and Nitrogen Deposition

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Executive Summary

One of the principal threats to natural resources on public lands managed by the National Park Service (NPS) is air pollution. Many air pollutants are emitted into the atmosphere outside park boundaries and are transported to the parks with the prevailing winds. Two of the most important are sulfur (S) and nitrogen (N), both of which can contribute to acidification of sensitive soil and surface water resources. Knowledge of the extent of resource sensitivity to acidic deposition is incomplete. The purpose of this assessment is to compile available information at the national scale to identify park resources that are known or thought to be sensitive to acidification from atmospheric deposition of acidifying S and N compounds. This assessment provides a first step in that process. This information will help federal land managers to assess current conditions, design monitoring programs to document and quantify changes over time, and better protect park resources.

This project evaluates the sensitivity of all Inventory and Monitoring (I&M) national parks in the United States to potential acidification effects caused by acidifying atmospheric deposition. Such effects can be caused by the addition of S, oxidized N (NO_x) and/or reduced N (NH_x) to natural ecosystems. Acidification can occur in both terrestrial (soil and soil water) and aquatic (fresh surface water) ecosystems. The addition of S and N from air pollution sources to national park ecosystems can alter plant, animal, and algal communities at all trophic levels and influence the mix of species that thrive in those ecosystems. The response is driven by both the amount of air pollutants deposited and the sensitivity of the receptors on which the pollutants are deposited.

This assessment includes consideration of three factors that influence acidification risk to park resources from atmospheric S and N deposition: Pollutant Exposure, inherent Ecosystem Sensitivity, and Park Protection mandates. National parks and networks are ranked according to each of these factors (themes). A Summary Risk ranking is calculated for each park and network based on averages of the three theme rankings.

Pollutant Exposure

Pollutant exposure is reflected in multiple variables that indicate emissions and deposition of S and N. The amounts of S and N emitted into the atmosphere vary across the United States, generally with highest emissions associated with electricity generating power plants; major population centers; and centers of energy, agricultural, and industrial development. The direction of atmospheric transport and distance traveled vary with chemical and meteorological conditions encountered along the path from emissions source to the location at which pollutants are deposited from the air to the ground surface. Deposition amounts also vary dramatically across the United States. This variability applies to the mechanism of deposition (wet, dry, cloud, fog), relative contribution of S versus N and oxidized versus reduced forms of N, and total quantity deposited.

Emissions inventories are only approximations and are less certain for reduced N, as compared with S and oxidized N. Deposition estimates are also uncertain, especially for the dry component of deposition. Cloud and fog deposition are not estimated regionally, and are important at some locations. Estimates of wet plus dry deposition constructed for this project are relatively coarse (12-km grid cells in the East; 36-km grid cells in the West) and do not fully capture spatial

variation in areas of complex terrain. Nevertheless, they do provide a reasonable approximation of patterns in total S and N deposition that potentially impact the ecosystems on which this deposition falls.

Ecosystem Effects

The addition of relatively large amounts of an acidifying substance (S and/or N) from atmospheric deposition can contribute to changes in the make-up of the terrestrial plant and aquatic algal and higher life form communities. Acidification can cause the more sensitive species to decline. Thus, the mix of species present in an ecosystem and the ecosystem biodiversity can change as a consequence of acid addition. Here, we summarize the extent and distribution of the fresh water aquatic and terrestrial ecosystems within the national parks that are thought to be most sensitive to the effects of acidification from atmospheric S and N deposition. These include remote lakes which often occur at high elevation, headwater streams, base-poor soils, and red spruce and sugar maple trees. Eutrophication effects are assessed in a companion report.

Streams and lakes vary in their sensitivity to acidification from acidic deposition. The surface waters that tend to be most sensitive to acidification are located on geological formations that contribute minimal quantities of base cations to drainage water. Acid-sensitive waters are often located at relatively high elevation, on steep slopes having shallow, base-poor soils.

Some kinds of plants appear to be more sensitive to acidification effects than others. Some lichens are especially sensitive, with documented effects occurring in the deposition range of only a few kilograms of S or N per hectare per year. Among the vascular plants, red spruce and sugar maple trees are known to be particularly sensitive.

Park Protection

All parks are equally deserving of protection, as per the NPS 1916 Organic Act and NPS Management Policies. Nevertheless, there are two types of public land designation that confer special protection against air pollution degradation: Wilderness and Class I. These designations were specified by the Wilderness Act and the Clean Air Act (CAA), respectively. Lands are identified for this acidification effects assessment that receive special Wilderness and/or Class I protection. These are the lands that are intended to receive the highest level of protection against adverse impacts caused by air pollution. Note, however, that NPS managers are mandated by the NPS Organic Act and NPS Management Policies to protect air quality and air quality-sensitive resources on all lands under their jurisdiction. Although some lands receive additional protection from the Wilderness Act and CAA, all NPS lands should be managed so as to leave them unimpaired for future generations.

Network and Park Rankings

The goal of this effort was to construct an overall risk assessment to estimate the relative risk to I&M parks, and to park networks, of acidification impacts from atmospheric S and N deposition. Parks and networks were ranked by perceived risk. The risk rankings were determined by combining three themes or layers of variables that represent Pollutant Exposure, inherent Ecosystem Sensitivity, and the extent of existing special Park Protection. Each of these themes

was quantified using variables that were widely available spatially, in most cases for the entire United States. Data layers were selected that provide insight into the relative differences among parks and networks in these three aspects of overall risk.

Networks were ranked for each emissions or deposition variable that was available spatially, from the network showing the lowest S and N Pollutant Exposure (lowest rank) to the network showing the highest S and N Pollutant Exposure (highest rank). These variable-specific rankings were then averaged to yield an overall Pollutant Exposure ranking for each of the 32 networks, where lower numbers (near 1) reflect lower Pollutant Exposure and higher numbers (near 32) reflect higher Pollutant Exposure. Results of this summary statistic are graphed by network.

Network designations were calculated in the same manner for the other two acidification themes: Ecosystem Sensitivity and level of Park Protection. A key element of the Ecosystem Sensitivity ranking was the location of parks within geographic areas known to be sensitive to soil and water acidification. This variable was constructed based on spatial coverages of acid sensitive resources compiled by Omernik and Powers (1983), Stoddard et al. (2003), and Sullivan et al. (2007). Ecosystem Sensitivity was also represented in part by the coverage of vegetative types expected to contain red spruce and/or sugar maple, the two tree species thought to be most sensitive to acidification and also by the abundance of high-elevation lakes and streams and low-order streams that might be especially prone to acidification. Low-order streams were defined as those having Strahler order 1 through 3. These are generally the small headwater wadeable streams that tend to be the steepest and coldest streams within the parks. Park Protection was represented by designation as wilderness and/or Class I area. Finally, an overall risk of acidification effects was calculated as the average of the rankings for the three themes discussed above.

As for the network rankings, park rankings were calculated individually for Pollutant Exposure, Ecosystem Sensitivity, and Park Protection metrics. Results of those rankings were summarized for all parks regardless of size in each of the individual network sections of the report. Average scores for each metric and results of the overall park-specific risk assessment for the 79 larger I&M parks (those larger than 100 square miles) were graphed and mapped.

The networks that had the highest calculated Summary Risk included two western mountain networks (North Coast and Cascades Network and Sierra Nevada Network), and one eastern network (Mid-Atlantic Network). Eleven of the larger (greater than 100 square miles in area) individual parks were ranked as having Very High overall risk of acidification. These included five eastern parks (Shenandoah [SHEN], Great Smoky Mountains [GRSM], Blue Ridge [BLRI], Delaware Water Gap [DEWA], and New River Gorge [NERI]); five western mountain parks (Mount Rainier [MORA], North Cascades [NOCA], Olympic [OLYM], Rocky Mountain [ROMO], Yosemite [YOSE]); and one park in the Upper Midwest (Voyageurs [VOYA]).

The risk rankings developed for this project should be considered as coarse first approximations of true risk. Confidence in the rankings will increase as scientific knowledge regarding Pollutant Exposure and inherent Ecosystem Sensitivity improve, and also as national-scale datasets that shed light on these issues become available and are depicted at finer scales. In some parks, such as GRSM and SHEN, detailed information about acidification risks to resources is currently available at a much finer scale than is shown in this national-level assessment. Detailed local

information should always be used by parks to evaluate resource conditions where it is available. However, information compiled for this risk assessment project should provide a mechanism to estimate relative risk among parks on a national scale, and identify areas where further research and monitoring may be necessary. This project should be considered one tool useful in the process of identifying risk to parks from atmospheric deposition of acidifying substances. As more information becomes available, the relative rankings of parks might change.

1. Background

1.1 Overall Project Approach

This project evaluates the sensitivity of all Inventory and Monitoring (I&M) national parks in the United States to acidification effects caused by atmospheric sulfur (S) and nitrogen (N) deposition. Such effects can be caused by the addition of S, oxidized N (NO_x) and/or reduced N (NH_x) to natural ecosystems. Acidification can occur in both terrestrial and aquatic ecosystems as soils, soil water, and surface water develop reduced capacity to buffer acidity contributed from the atmosphere. The addition of acidity from S and N sources of air pollution to national park ecosystems can alter plant, animal, and algal communities and influence the mix of species that thrive in those ecosystems. Atmospheric deposition of N can also contribute to nutrient enrichment effects; these nutrient N enrichment topics are addressed in a companion report (Sullivan et al. 2011).

This assessment includes consideration of several factors that influence risk to park resources: N and S Pollutant Exposure, inherent Ecosystem Sensitivity, and Park Protection mandates. The Pollutant Exposure ranking is influenced, in part, by available data on the magnitude of emission sources and their location relative to the I&M parks. Atmospheric wet and dry deposition estimates and proximity to human population centers and agricultural source areas also influence the Pollutant Exposure ranking. Ecosystem Sensitivity varies greatly. For example, streams and lakes vary in their sensitivity to acidification, depending in part on local geology, slope, elevation, soil condition, and water flow paths. Terrestrial sensitivity varies according to soil conditions and by the plant and lichen species present; some species are thought to be more susceptible to acidification impacts from low to moderate levels of S and N addition than others. The degree of special Park Protection also influences risk ranking in this assessment. All parks receive protection under the Organic Act and NPS Management Policies. All parks are to be managed to preserve resources unimpaired for future generations. Nevertheless, some parks, especially those designated as Class I or Wilderness, receive special protection from air pollution-caused degradation. The degree of special protection conferred by these regulations is evaluated by computing the extent to which park lands are designated Class I and/or Wilderness.

1.2 Pollutant Exposure

1.2.1 Emissions into the Atmosphere

Sulfur emissions in the United States derive primarily from electricity generating power plants, and secondarily from industrial and mobile sources. Sulfur is commonly emitted into the atmosphere as sulfur dioxide (SO_2), released when S-containing coal or other fuel is burned. There are two major kinds of human-caused emissions of N into the atmosphere in the United States: NO_x and NH_x. The oxidized forms (primarily nitrogen dioxide) derive mainly from motor vehicles, power plants, and industrial facilities. The reduced forms (primarily ammonia) derive mainly from agriculture, via volatilization of N contained in animal manures and fertilizers.

The amounts of S and N emitted into the atmosphere vary across the United States, generally with highest emissions near coal-fired power plants and in and around major population centers and centers of energy, agricultural, and industrial development. Total S and N emissions sources

are mapped by county in Maps 1 and 2, based on U.S. Environmental Protection Agency (EPA) emissions estimates for the United States for the year 2002. These acid precursor emissions are dispersed through the atmosphere and transported with the prevailing winds. Some emissions are preferentially deposited to the ground in proximity to the source. When the emitted S or N is transported vertically upward by convection to the middle and upper troposphere, however, it can be transported long distances from the source areas. The direction of atmospheric transport and distance traveled vary with chemical and meteorological conditions encountered along the path from emissions source to the location at which pollutants are deposited from the air to the ground surface.

1.2.2 Atmospheric Deposition

In order for atmospheric S or N emitted from human-caused sources to cause environmental impacts (for example to soil, plants, lichens, or aquatic organisms), it must first be deposited from the air to the ground surface. Although this transfer is commonly called "acid rain" in the popular vernacular, rain only accounts for part of the transfer. Atmospheric pollutants move to the ground in rain, snow, clouds, and as dry particles and gases. The overall transfer process is called acidic deposition, which can be broken down into wet, dry, and cloud or fog components. This deposition can fall on multiple surfaces (e.g., plant foliage, ground, water, snow). Wet deposition has been monitored for more than 20 years at many locations around the country by the National Atmospheric Deposition Program, National Trends Network (NADP/NTN) by continuously collecting and analyzing samples of rain and snow. These monitoring sites are present in sufficient numbers in the eastern United States to allow spatial interpolation of wet deposition estimates across the landscape. Dry and cloud or fog deposition are more difficult to measure. Dry deposition can be estimated from measurements or model projections of pollutant concentrations in the air, assuming a rate of transfer from the air to the earth surface. A fairly sparse network of dry deposition monitors is operated by the Clean Air Status and Trends Network (CASTNet). Cloud deposition has only been measured at a few locations because of the difficulty and expense of collecting such data. In general, cloud deposition in the eastern United States is assumed to occur primarily at elevations above about 1,000 m and to be quantitatively important above about 1,500 m. The uncertainties in measuring or estimating deposition are expected to influence the outcome of this assessment.

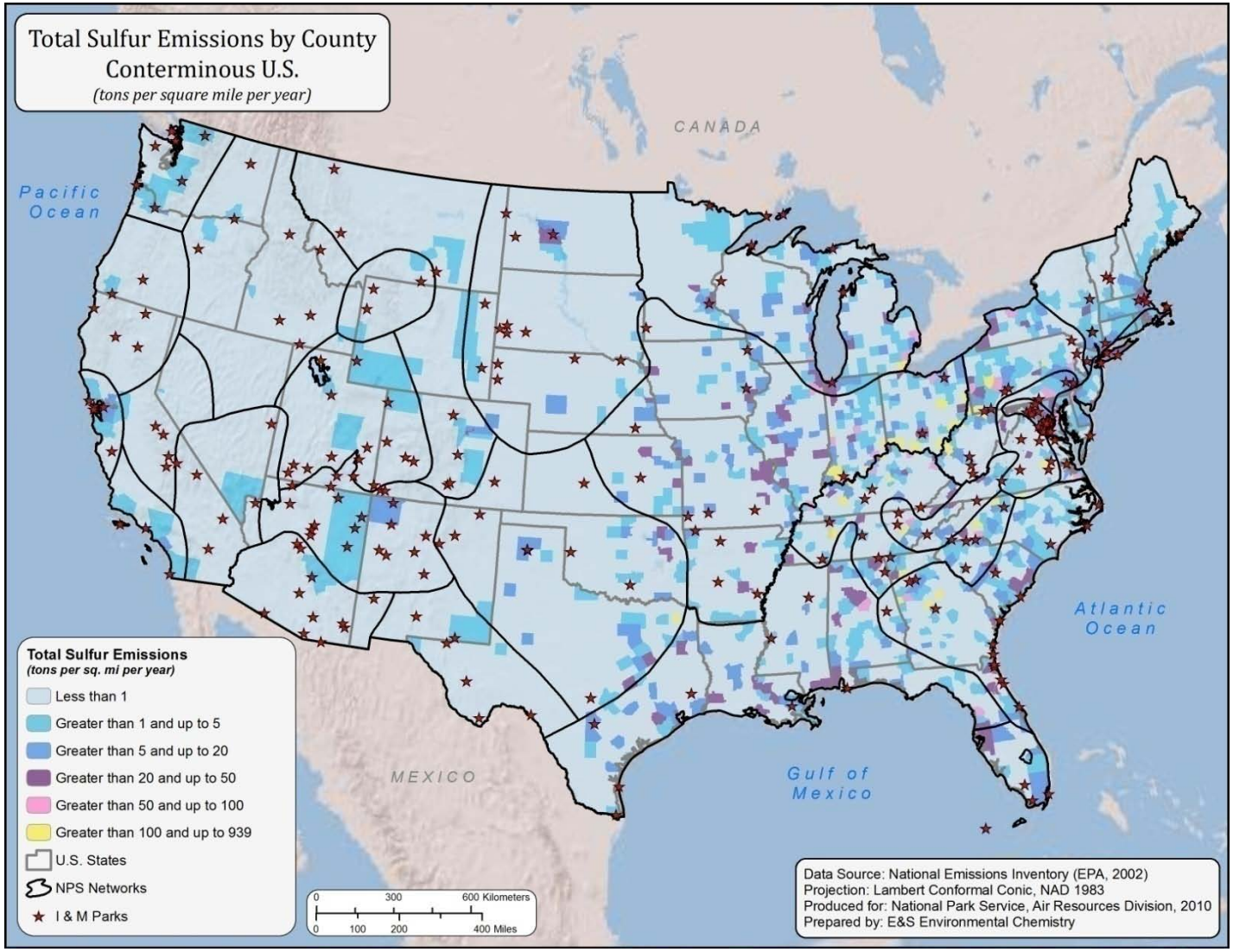
Sulfur is largely deposited as, or converted into shortly after being deposited, sulfate (SO_4^{2-}). In some ecosystems (mainly unglaciated portions of the Appalachian Mountains), much of the incoming S is adsorbed to the more highly weathered soils in these areas and therefore does not immediately contribute to acidification of soils or drainage water. In other, mainly glaciated, ecosystems, SO_4^{2-} acts as a mobile anion, moving more or less directly through soil and into surface water. Mobile SO_4^{2-} contributes to the acidification of soil, soil water, and surface water.

Both S and N deposition vary dramatically across the United States. This variability applies to the mechanism of deposition (wet, dry, cloud, fog), relative contribution of S versus N and oxidized versus reduced forms of N, and total quantity deposited. Wet deposition predominates in some areas. Nevertheless, dry deposition is much higher than wet deposition at some locations, mostly notably in and around the Los Angeles basin and near large emissions sources. Cloud deposition can constitute as much as half of the total deposition in high mountain areas such as portions of GRSM and other areas in the eastern United States that lie above about 1,500 m elevation. Coniferous trees have greater leaf surface area than do deciduous trees, shrubs,

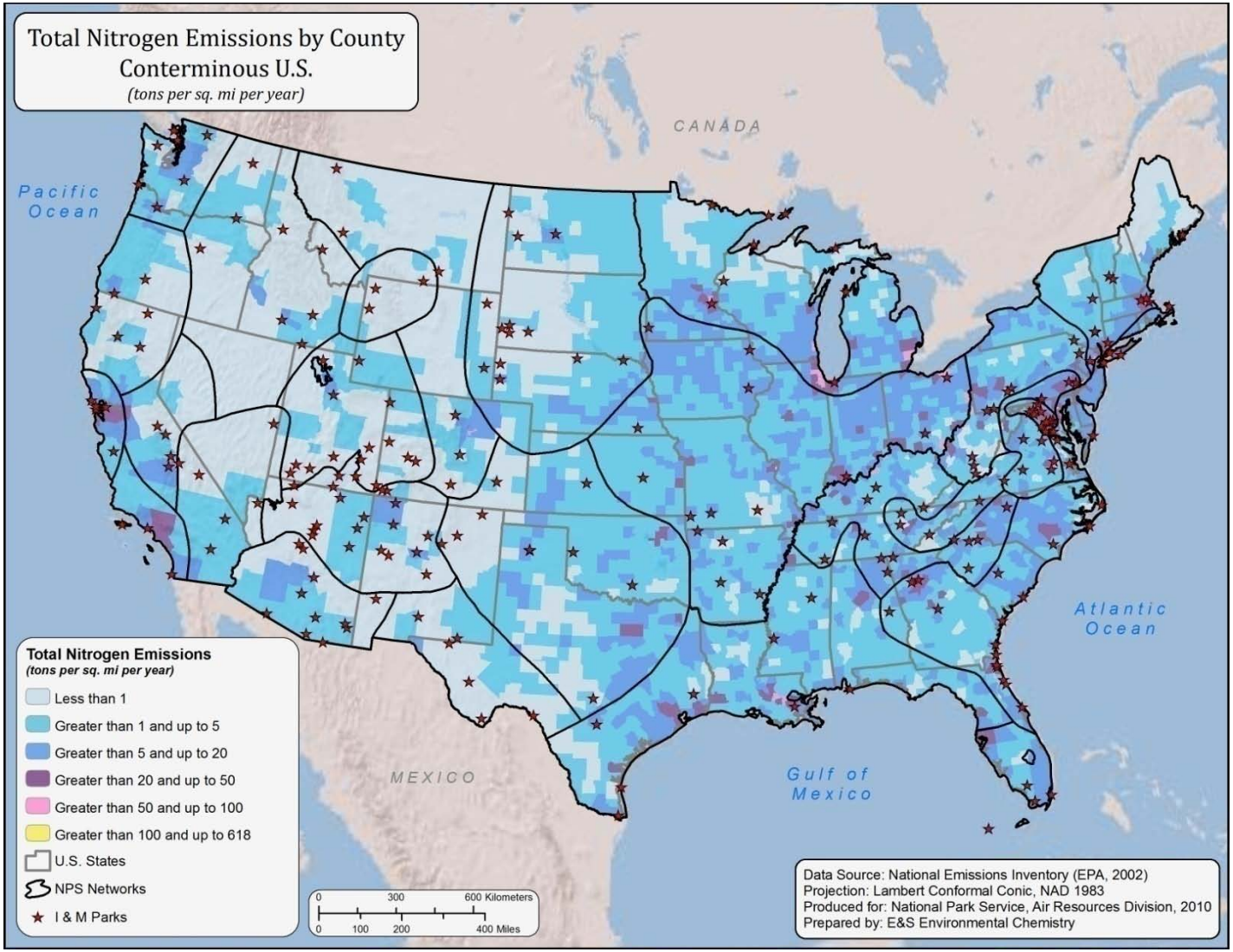
grasses, or forbs; therefore, dry deposition to conifer needles is generally higher than dry deposition to other vegetative surfaces. Reduced N deposition can be especially high near and downwind of confined animal feeding operations.

Sulfur deposition is substantially higher in the eastern United States than in the western United States. In general, atmospheric N deposition is relatively high throughout much of the eastern United States and at various hot-spots in the West, including downwind of the Los Angeles area and in portions of the Rocky Mountains. In some places, both total S and total N deposition have likely increased nearly 10-fold over the past century due to energy, agricultural, industrial, and transportation development. Patterns of deposition are highly complex due to the influence of such variables as meteorology, atmospheric transport, atmospheric chemistry, precipitation patterns, and vegetative cover. In some places, the total amount of deposition can vary several-fold over relatively short distances, especially in complex mountainous terrain.

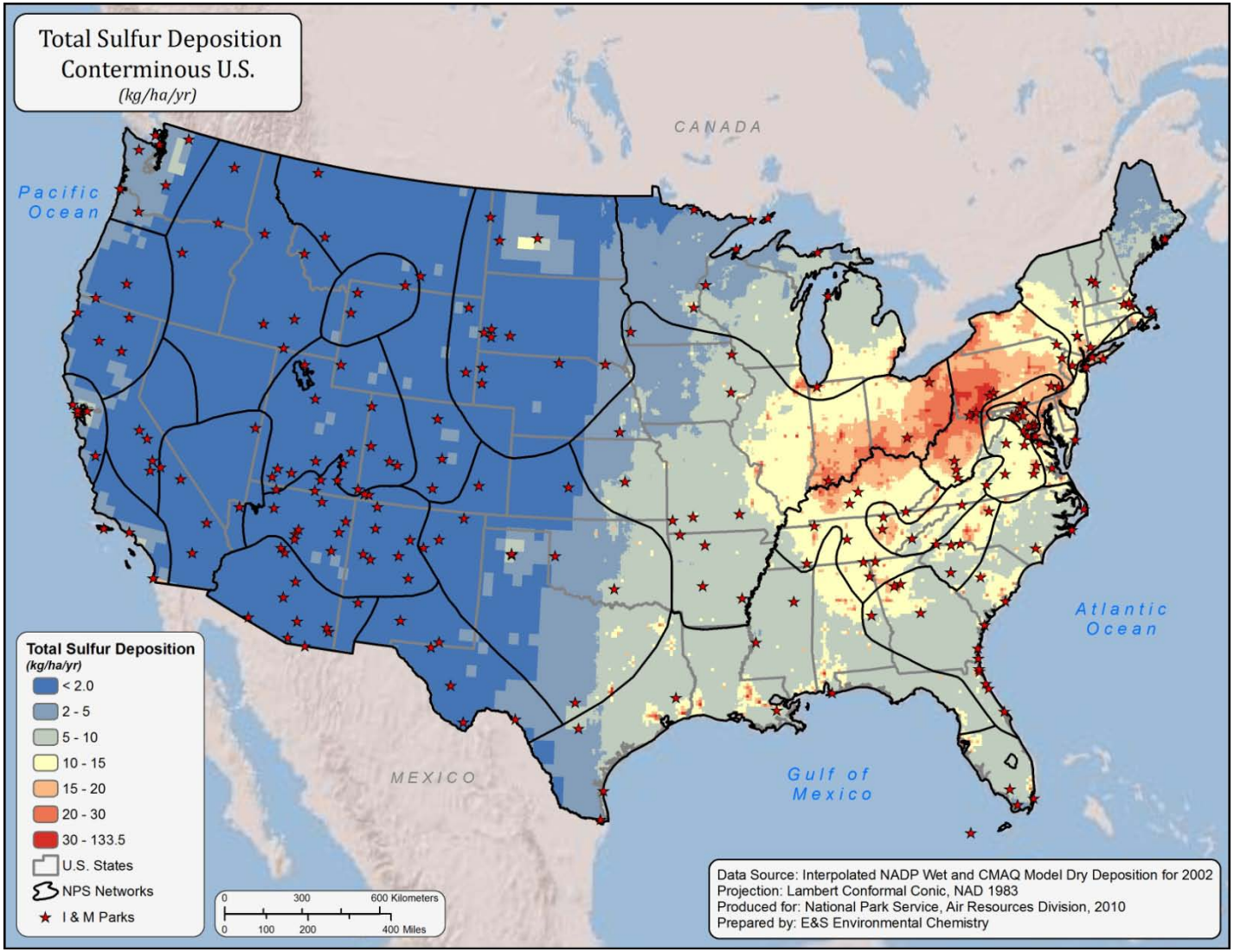
Wet deposition of S and N measured by NADP/NTN was mapped for the eastern United States, using the approach of Grimm and Lynch (1997), by applying a statistical interpolation procedure that corrects for the effects of changing elevation on precipitation amount (data provided by J. Grimm). For the western United States, wet deposition monitoring sites are sparsely located. We therefore estimated spatial patterns in wet deposition throughout the western United States for this project using output from the Community Multiscale Air Quality (CMAQ) atmospheric transport model (data provided by R. Dennis, U.S. EPA). Estimates of dry deposition were added to interpolated wet deposition for the analysis presented here, using output for both the East and the West from CMAQ. The resulting estimates of total wet plus dry S and N deposition, including both oxidized and reduced forms of N, are shown in Maps 3 and 4. There may be additional cloud deposition at the highest elevation areas in some regions and fog deposition at coastal locations. Neither of these forms of deposition are well quantified. Uncertainty is high for estimating dry deposition. These estimates of wet plus dry deposition are relatively coarse (12-km CMAQ grid cells in the East; 36-km CMAQ grid cells in the West) and do not fully capture spatial variation in areas of complex terrain. Nevertheless, they do provide a reasonable approximation of patterns in total S and N deposition that potentially impact the ecosystems on which this deposition falls.



Map 1. Total annual sulfur emissions by county for the year 2002 throughout the conterminous United States. Also shown are the locations of I&M parks.



Map 2. Total annual nitrogen emissions by county for the year 2002 throughout the conterminous United States. Also shown are the locations of I&M parks.



Map 3. Total N deposition for the conterminous United States for the year 2002, expressed in units of kilograms of N deposited from the atmosphere to the earth surface per hectare per year.

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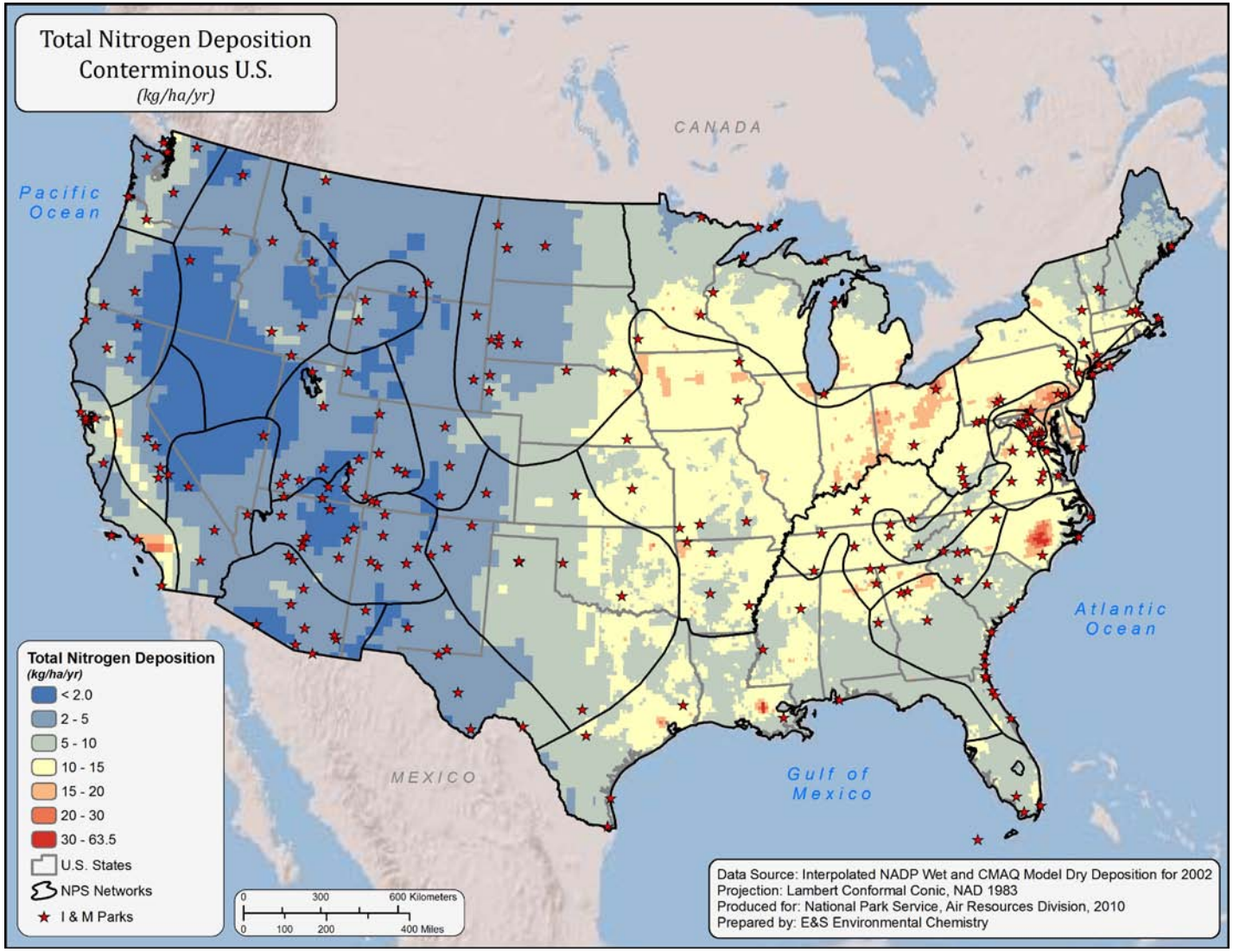


Map 4. Total S deposition for the conterminous United States for the year 2002, expressed in units of kilograms of S deposited from the atmosphere to the earth surface per hectare per year.

1.3 Ecosystems Effects

We summarize here the extent and distribution of the fresh water aquatic and terrestrial ecosystems within the national parks that are thought to be most sensitive to the effects of acidification from atmospheric S and N deposition. For aquatic ecosystems, these include remote lakes which often occur at high elevation, and headwater (Strahler order 1–3) streams. Acid-sensitive waters most commonly occur in areas of high elevation and steep terrain, on shallow soils and bedrock types that provide limited base cations to drainage water.

Atmospheric deposition of S and/or N can cause acidification of soil, soil water, lakes, and streams. In most portions of the United States that have experienced soil and water acidification attributable to air pollution, such effects have mainly been due to S inputs. There are, however, some regions, especially in the western United States, where resources are more threatened or have been more affected by N inputs than by S inputs. This is at least partially due to the low levels of S deposition received at most western locations. There are also regions where both atmospheric S and N contribute substantially to the observed acidification. These include portions of the Northeast, West Virginia, and high elevations in North Carolina and Tennessee.

1.3.1 Terrestrial Effects

Relatively little S is taken up from the soil into plant roots. However, N can be transported from plant surfaces to the interior of plant leaves through the leaf stomata. It can also be washed from plant surfaces into the soil with rainfall. Once N makes its way into plant tissues or into soil it can cause several kinds of ecological effects. These effects can be broadly characterized as nutrient enrichment effects and acidification effects. This report addresses acidification effects and an associated process called N saturation.

Within the soil, there are many conversions and transformations of the deposited N that take place, often facilitated by bacteria and fungi. The N form can change rather rapidly. Different plants and different kinds of algae vary in their needs for N nutrition. Some prefer oxidized forms; some prefer reduced forms; some can use small organic N molecules. When N leaches from the soil into drainage water, and eventually to a stream or lake, it is mostly in the nitrate (NO_3^-) form. When N deposition and its effects are discussed, all these different forms of N, and others, are included.

The release of base cations from the soil into soil water through weathering, cation exchange, and mineralization contributes to neutralization of acidity (van Breemen et al. 1983). If the acidity is associated with anions that are mobile within the soil environment, such as SO_4^{2-} and NO_3^-, cations can be leached into ground waters and eventually to surface waters. Loss of base cations from soil is partly a natural process. The limited mobility of anions associated with naturally derived organic acids and carbonic acid controls the rate of base cation leaching under conditions of low atmospheric deposition of S and N. Because inputs of S and N in acidic deposition supply anions that are often highly mobile in the soil, these mineral acid anions accelerate base cation leaching (Cronan et al. 1978). Depletion of nutrient base cations, especially calcium (Ca), can cause damage to acid-sensitive plants.

Two tree species (red spruce and sugar maple) are known to be highly susceptible to damage from acidic deposition. The general distribution of these species is shown in Map 5. Some national parks have extensive coverage of vegetation types thought to include one or both of these sensitive tree species. Other national parks are dominated by other forest vegetation or some other cover type thought to be less sensitive to such effects at S and N deposition levels that are commonly found in the United States. Although acidification effects in the United States are expected to be especially pronounced in the plant communities that include these tree species, the same kinds of effects might also occur in other vegetation types. Nevertheless, effects on vascular plant species other than red spruce and sugar maple are poorly documented in this country.

Many lichen species are known to be sensitive to air pollution. Effects seem to be more clearly associated with N inputs than with S inputs (Bobbink et al. 2003, Geiser and Neitlich 2007, Glavich and Geiser 2008). These effects may be driven by nutrient enrichment processes more than acidification processes. They are discussed in the companion report on nutrient enrichment sensitivities in the I&M parks. It is also likely, however, that S air pollution has impacted the distribution of lichens, especially in the eastern United States, but there are no broad regional or national data available to evaluate that.

There are four major issues that are potentially important with respect to terrestrial effects of atmospheric S and N deposition:

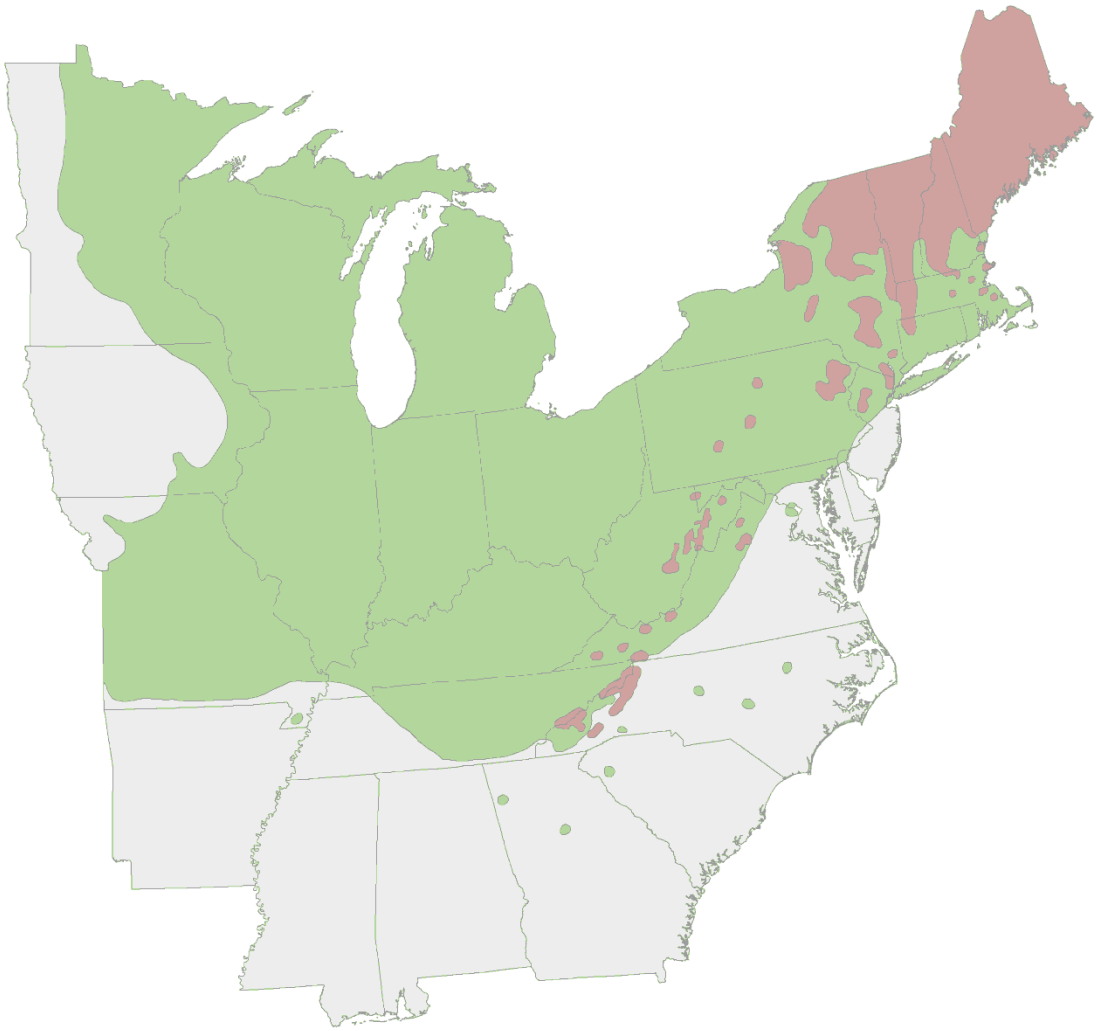
1. Toxicity of aluminum (Al) to plant roots and/or foliage,
2. Depletion of Ca and other nutrient base cations from soil,
3. N saturation, and
4. Nutrient enrichment effects.

Toxicity, base cation depletion, and N saturation effects are described below. Nutrient enrichment effects are covered in a companion report:

> Sullivan, T. J., T. C. McDonnell, G. T. McPherson, S. D. Mackey, and D. Moore. 2011. Evaluation of the sensitivity of inventory and monitoring national parks to nutrient enrichment effects from atmospheric nitrogen deposition: main report. Natural Resource Report NPS/NRPC/ARD/NRR—2011/313. National Park Service, Denver, Colorado.
>
> Available from Air Resources Division of the NPS (http://www.nature.nps.gov/air/Permits/ARIS/networks/n-sensitivity.cfm).

1.3.1.1 Aluminum Toxicity

Most acidification effects on plants are mediated through the soil, and are governed by Al toxicity and nutrient base cation (Ca, magnesium [Mg], potassium [K]) deficiencies. These two factors are closely related. The first is discussed here and the second is discussed in the section that follows. At high concentration in soil water, Al is toxic to plant roots. Plants affected by high Al concentrations in soil water can show reduced root growth. This limits the ability of the plant to take up water and nutrients, especially Ca (Parker et al. 1989).



Map 5. General distribution of red spruce (rose) and sugar maple (green) within the United States. Source: Little (1971; http://esp.cr.usgs.gov/data/atlas/little/)

One of the key biogeochemical processes that is altered by acidic deposition is the mobilization of Al from soils to waters (Cronan and Schofield 1979, Mason and Seip 1985), causing potential toxic impacts to fish and other aquatic organisms. Aluminum solubility increases at pH values below about 5.5. Aluminum concentrations in drainage waters having pH below about 5.0 are often an order of magnitude higher than in waters having pH above 6.0.

Red spruce trees in the eastern United States died at a rapid pace in recent decades. This mortality was linked to exposure of foliage to acidic cloud water and an increase in the amount of dissolved inorganic monomeric Al (Al_i^{n+}) compared with dissolved Ca^{2+} in soil water. Some of the red spruce decline occurred at high-elevation sites which frequently experience cloud cover. Much of the total atmospheric S and N deposition at such locations probably comes in the form of cloud deposition, which is often more acidic than acid rain.

The leaching of atmospherically deposited SO_4^{2-} to soil waters, and eventually to surface waters, is the dominant mechanism controlling soil acidification and Al toxicity to plants at most acid-impacted areas in the United States. The various aspects of ecosystem acidification are largely controlled by SO_4^{2-} mobility in most affected ecosystems. Nitrate mobility is also important in some locations, but the dominant mobile strong acid anion is usually SO_4^{2-}.

In regions of the United States affected by acidic deposition, the total concentration of mineral acid anions in surface waters (mainly SO_4^{2-}) has changed from historical conditions. In response to these changes in SO_4^{2-} concentration, the concentrations of other ions in surface water must also have changed to maintain electroneutrality. The leaching of SO_4^{2-} does not directly cause environmental effects. Rather, it is the changes in other ions that are responsible for environmental effects of drainage water acidification. As SO_4^{2-} concentration increased over time, other anions (mainly bicarbonate, HCO_3^-) must have decreased and/or cations (e.g., base cations, hydrogen ion [H^+], or Al_i^{n+}) must have increased to maintain the charge balance whereby the sum of the cations equals the sum of the anions.

1.3.1.2 Depletion of Base Cations from Soil

Base cations are common in rocks and soils, but occur largely in forms that are unavailable to plants. There is also a pool of bioavailable base cations (termed exchangeable base cations) that are adsorbed to negatively charged surfaces of soil particles. Base cations in this pool are gradually leached from the soil in drainage water, but are constantly resupplied through weathering. Weathering slowly breaks down rocks and minerals, releasing base cations to the pool of adsorbed exchangeable base cations on the soil. The balance between base cation supply and base cation loss determines whether the pool of available base cations is increasing or decreasing in size over time. Enhanced leaching of base cations by acidic deposition in some cases can deplete the soil of exchangeable bases faster than they are resupplied (Cowling and Dochinger 1980). Nutrient base cations, including Ca, Mg, and K, are taken up through plant roots from the soil water to satisfy plant nutritional needs. In soils having low base saturation, exchangeable Ca^{2+}, Mg^{2+}, or K^+ can be depleted so much that nutrient deficiencies develop in vegetation.

The hardwood tree species most commonly associated with acidification effects is sugar maple. It is distributed throughout the northeastern United States and central Appalachian Mountain region as a component of the northern hardwood forest. Acidification effects have not been as widely demonstrated for sugar maple as they have for red spruce. Nevertheless, several studies in the United States, mainly in Pennsylvania, have indicated that sugar maple decline is linked to the occurrence of relatively high levels of acidic deposition and base-poor soils and is linked to Ca depletion.

The health of sugar maple trees is strongly influenced by the availability of Ca and perhaps other base cations in soil. Trees that grow on soils having low base cation supply are stressed and consequently often become more susceptible to damage from defoliating insects, drought, and extreme weather. The overall response includes death of mature trees and poor regeneration of seedlings.

Soil acidification and depletion of soil base cations may be contributing to sugar maple mortality on sites having marginal soils. Sugar maple dieback at 19 sites in northwestern and northcentral

Pennsylvania and southwestern New York was correlated with combined stress from defoliation and soil deficiencies of Mg and Ca (Horsley et al. 1999) . Dieback occurred predominately on ridgetops and on upper slopes, where soil base cation availability was much lower than at middle and lower slopes (Bailey et al. 1999).

1.3.1.3 Nitrogen Saturation

An undisturbed, unpolluted forest typically uses and stores, mostly in the soil, almost all of the small amount of N that it receives from atmospheric deposition. This N is cycled between soil and vegetation. However, forests have a maximum capacity to store N that they receive from outside the watershed. This capacity is determined by the plant species present on the site and the history of logging and other disturbances that previously removed some of the N that was stored in the soil and trees. When N inputs exceed this storage capacity, the site becomes N saturated, and more of the incoming N leaches as NO_3^- to soil water and eventually to streams and lakes. This leaching of NO_3^- can contribute to soil acidification, with harmful consequences to plants. In the early stages of N saturation, the trees may actually grow faster because they are being fertilized by N, which is the most important growth-limiting nutrient in many forests. During the latter stages of N saturation, tree health deteriorates and the forest may release to drainage water more N than is coming into the watershed from atmospheric deposition. Under conditions of advanced N saturation, tree growth declines and sensitive tree species die in response to acidification and base cation depletion (U.S. EPA 2008).

Some terrestrial ecosystems, especially at high elevation, have become N-saturated and high levels of N deposition have contributed to increased NO_3^- leaching losses in drainage water (Aber et al. 1989, 1998; Stoddard 1994). The term N-saturated reflects a condition whereby the input of N to the ecosystem exceeds the nutritional requirements of terrestrial biota, and a substantial fraction of the incoming N leaches out of the ecosystem as NO_3^- in groundwater and surface water. This enhanced NO_3^- leaching can remove Ca^{2+} and other base cations from soil and cause acidification of soil and water.

Forest growth in the United States is generally limited by the availability of N (Aber et al. 1989). Most forests take up the N provided by atmospheric deposition with few or no signs of N-saturation. However, at some locations, decades of atmospheric N deposition has increased N supply in the soil to levels that are no longer growth limiting to forest vegetation. Excess N at such sites increases net nitrification (formation of NO_3^- from NH_4^+ and organic N) and NO_3^- leaching (Aber et al. 2003).

In general, hardwood forest stands in the eastern United States have not progressed toward N-saturation as rapidly or as far as spruce stands. Hardwood forests may have a greater capacity for N retention than coniferous forests. In addition, hardwood forests are often located at lower elevation and receive lower atmospheric inputs of N (U.S. EPA 2008).

Thus, atmospheric deposition of N has increased N availability in soils at some locations, which has led to increased nitrification and associated acidification of soil and soil water. The N retention capacity of soils is strongly dependant on land use history, however, so the relationships between N deposition and ecosystem N status are variable. In general, atmospheric deposition of about 10 kg N/ha/yr or higher is required in order for appreciable amounts of NO_3^- to leach to surface waters in the eastern United States (U.S. EPA 2008).

High concentrations of NO_3^- in soil solution appear to be largely responsible for the potentially toxic peaks in Al concentration that sometimes occur in soil solution. Sulfate may also play a role by serving to elevate chronic Al concentrations (Eagar 1996, U.S. EPA 2008). Many studies in the southern Appalachian Mountains (cf., Joslin et al. 1992; Van Miegroet et al. 1992a,b; Joslin and Wolfe 1994; Nodvin et al. 1995) have found high concentrations of NO_3^- in soil water and stream water at high-elevation spruce-fir forest locations. This NO_3^- leaching is believed to have been caused by high N deposition, low N uptake by forest vegetation, and inherently high N release from soils. Forest age also affects N uptake by vegetation. Mature trees take up relatively small amounts of N for new growth and often show higher NO_3^- leaching than younger, faster growing stands (Goodale and Aber 2001).

1.3.2 Aquatic Effects

Surface water acidification entails a decrease in acid neutralizing capacity (ANC), usually a decrease in pH, and often an increase in the concentration of Al_i^{n+}. Many species of aquatic biota are sensitive to acidification, including fish, invertebrates, and phytoplankton.

ANC is the most widely used water chemistry indicator for both acidic deposition sensitivity and effects. It can be measured in the laboratory by Gran titration or defined as the difference between the measured base cation and mineral acid anion concentrations in water:

$$ANC = (Ca^{2+} + Mg^{2+} + K^+ + Na^+ + NH_4^+) - (SO_4^{2-} + NO_3^- + Cl^-) \quad (1)$$

Surface water ANC reflects the end result of all of the chemical, physical, and biological interactions that occur as atmospheric deposition and precipitation move from the atmosphere into the soil and eventually emerge as drainage water in a stream or lake. ANC reflects the relative balance between base cations and strong acid anions in solution. If the sum of the base cation concentrations (in equivalence units) exceeds those of the strong acid anions, the water will have positive ANC. To the extent that the base cation sum exceeds the strong acid anion sum, the ANC will be higher. Higher ANC is generally associated with higher pH and Ca^{2+} concentrations; lower ANC is generally associated with higher H^+ and Al^{n+} concentrations and a greater likelihood of toxicity to aquatic biota.

ANC concentrations can be grouped into five major classes: Acute Concern (less than 0 μeq/L), Severe Concern (0 to 20 μeq/L), Elevated Concern (20 to 50 μeq/L), Moderate Concern (50 to 100 μeq/L), and Low Concern (greater than 100 μeq/L), with each range representing a probability of ecological damage to the community (Cosby et al. 2006). Biota are generally not harmed when ANC values are above 100 μeq/L (U.S. EPA 2009). Some surface waters have ANC below 100 μeq/L even in the absence of acidic deposition.

A number of factors influence the sensitivity of aquatic ecosystems to acidification in response to S and N deposition. In particular, the geologic composition of a region plays a dominant role in influencing the sensitivity of surface waters to the effects of acidic deposition. Bedrock geology formed the basis for a national map of surface water sensitivity (Norton et al. 1982) and has been used in numerous acidification studies of more limited extent (e.g., Dise, 1984, Bricker and Rice, 1989, Sullivan et al. 2007). Most of the major concentrations of low-ANC surface waters are located in areas of the United States that are underlain by bedrock resistant to weathering (U.S. EPA 2008).

Soil chemistry, land use, watershed slope, and hydrologic flowpath also contribute to the sensitivity of surface waters to acidic deposition. Land disturbance and consequent exposure of S-bearing minerals to oxidation, loss of base cations through erosion and timber harvesting, and change in N status of the forest through timber management can all influence the relative availability of mobile mineral acid anions (SO_4^{2-}, NO_3^-) and base cations (Ca^{2+}, Mg^{2+}, K^+, Na^+) in drainage water.

Effects on lakes and streams are strongly influenced by the flowpath of water through the terrestrial watershed. The depth and chemical composition of soils, talus, and colluvium (sediment) and the slope of the watershed collectively determine the residence time of subsurface water within the watershed, extent to which snowmelt and rainfall runoff interact with soils and geologic materials, and consequently the extent of NO_3^- leaching, base cation mobilization, and acid neutralization within the watershed (Turner et al. 1990, Sullivan 2000). Surface waters can have different sensitivities to acidification depending on the relative contributions of near-surface drainage water and deeper groundwater (Eilers et al. 1983, Chen et al. 1984, Driscoll et al. 1991). Acidic deposition that falls as precipitation directly on the lake surface may eventually be neutralized by in-lake reduction processes which are controlled in part by hydraulic residence time (Baker and Brezonik 1988). Natural hydrologic events also alter acidification and neutralization processes during snowmelt and change flowpaths during extended droughts (Webster et al. 1990).

The concentration of acid anions in solution, including SO_4^{2-}, NO_3^-, and organic acid anions, partially regulate the extent to which drainage waters will be acidified by acidic deposition. Acidic deposition allows natural soil acidification and cation leaching processes to occur at greater depths in the soil profile, allowing water that is rich in SO_4^{2-} or NO_3^- to flow from mineral soil horizons into drainage waters. If these anions are charge-balanced by H^+ or Al_i^{n+} cations, the water will have low pH and could be toxic to aquatic biota. If they are charge-balanced by base cations, the base cation reserves of the soil can become depleted, but the surface water will not be acidified (U.S. EPA 2008). Most watersheds in the eastern United States are not exhibiting much ANC and pH recovery of drainage water in response to recent large decreases in S deposition due to implementation of emissions control programs under the Clean Air Act (CAA). This limited recovery is partly due to decreased base cation concentrations in surface water.

Regions of the United States that contain appreciable numbers of lakes and streams with low ANC (less than about 50 to 100 μeq/L) include portions of the Northeast (New England and the Adirondack and Catskill mountains), the Southeast (the Appalachian Mountains and portions of northern Florida), the Upper Midwest, and mountainous portions of the western United States (Charles 1991). In particular, the Adirondack and Appalachian mountains, and to a lesser extent the Upper Midwest, include many acidified surface waters that have been impacted by acidic deposition. Portions of northern Florida also contain many acidic and low-ANC lakes and streams, although the role of acidic deposition in these areas is less clear. The western United States contains many of the surface waters most susceptible to potential acidification effects, but the levels of acidic deposition in the West are relatively low in most areas, acidic surface waters are rare, and the extent of chronic surface water acidification that has occurred to date has probably been limited (U.S. EPA 2008).

Areas of the United States that are sensitive to acidification in response to acidic deposition have been identified in a number of studies. Omernik and Powers (1983) constructed a national map of surface water alkalinity that formed the basis for many subsequent studies. Baker et al. (1990) identified six high interest subpopulations that accounted for most of the U.S. surface waters that had ANC $\leq$ 0 μeq/L and for which acidic deposition had been identified as the likely dominant source.

- Southwestern Adirondacks
- New England Uplands
- Eastern Upper Midwest
- Forested Mid-Atlantic Highlands
- Mid-Atlantic Coastal Plain
- Northern Florida Highlands

Stoddard et al. (2003) presented a map of acid-sensitive regions of the eastern United States where lakes and streams occur that are likely to be affected by acidic deposition. The map showed considerable overlap with the areas of high interest identified by Baker et al. (1990).

Sullivan et al. (2007) mapped portions of the southern Appalachian region that contained the vast majority of the known (from a dataset of over 900 streams) acidic (ANC $\leq$ 0 μeq/L) and low-ANC ($\leq$ 20 μeq/L) streams. This map was based on the presence of siliciclastic lithology (silica-based bedrock with low base cation supply) and elevation.

High-elevation lakes and streams are of particular interest with respect to potential impacts attributable to acidic deposition. Many waters at high-elevation tend to be dilute, and this contributes to increased risk of acidification and biological change from acid input. Because soils at high elevation are often shallow and poorly developed, with much exposed bedrock, the supply of base cations with which to neutralize acidity can be low. Furthermore, there is typically little to no human development in high-elevation watersheds, and atmospheric sources often provide the dominant source of mineral acids to these watersheds.

1.4 Park Protection

All parks are equally deserving of protection, as per the NPS 1916 Organic Act, which states that the NPS will:

> promote and regulate the use of…national parks…by such means and measures as conform to the fundamental purpose of the said parks…which purpose is to conserve the scenery and the natural and historic objects and wild life therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations (16 U.S.C. 1).

The Organic Act and its 1970 and 1978 amendments do not directly address air pollution effects. However, they do specify what resources should be protected in the National Park system. The 1978 amendments clarify the importance Congress placed on protecting park resources:

> The authorization of activities shall be construed and the protection, management, and administration of these areas shall be conducted in light of the high public value and integrity of the National Park System and shall not be exercised in derogation of the values and purposes for which these various areas have been established, except as may have been or shall be directly and specifically provided by the Congress (16 U.S.C. 1a-1).

Each of these laws is essentially a charter from Congress providing a purpose for parks, wildernesses, and refuges, and establishing broad management objectives for these areas. NPS Management Policies more specifically address air quality:

> …….the Service will seek to perpetuate the best possible air quality in parks to (1) preserve natural resources and systems; (2) preserve cultural resources; and (3) sustain visitor enjoyment, human health, and scenic vistas……The Service will actively promote and pursue measures to protect these values [air quality related values, AQRVs] from the adverse impacts of air pollution. In cases of doubt as to the impacts of existing or potential air pollution on park resources, the Service will err on the side of protecting air quality and related values for future generations.

There are two types of public land designation that confer additional and special protection against air pollution degradation: wilderness and Class I. These designations were specified by the Wilderness Act and the CAA, respectively. Therefore, lands are identified for this acidification assessment that receive special wilderness and/or Class I protection. These are the lands that are intended to receive the highest level of protection against adverse impacts caused by air pollution.

The Wilderness Act sets aside a subset of the public lands where natural processes are allowed to dominate.

> Wilderness areas… shall be administered for the use of the American people in such a manner as will leave them unimpaired for future use and enjoyment as wilderness …. (16 U.S.C. Sec. §1131)

The CAA designates some public lands as Class I and grants federal land managers an affirmative responsibility to protect these areas from adverse impacts caused by air pollution. The CAA provides the legal framework for federal land managers to preserve and protect AQRVs from pollution sources both within and outside park boundaries.

The Prevention of Significant Deterioration section of the CAA establishes ceilings on allowable additional amounts of air pollution over baseline levels in clean air areas. It requires EPA or the states to provide to the federal land managers notice of any proposed major emitting facility whose emissions may affect a Class I area (42 U.S.C. §7475(d)(2)(A)). Class I areas include national parks larger than 6,000 acres and national wilderness areas and national memorial parks which exceed 5,000 acres, and which were in existence on August 7, 1977. Additions to the boundaries of previously existing Class I areas are also automatically designated as Class I areas. Currently, 48 areas in the National Park system are designated as Class I.

2. Methods

The goal of this effort was to construct an overall risk assessment to estimate the relative risk to I&M parks, and to park networks, of acidification impacts from atmospheric S and N deposition. Parks and networks were ranked by perceived risk. The risk rankings were determined by combining three layers of variables that represent 1) Pollutant Exposure, 2) inherent Ecosystem Sensitivity, and 3) the extent of existing special Park Protection. Each of these layers was quantified using variables that were available spatially throughout much or all of the United States and that provided insight into the relative differences among parks in these three aspects (or themes) of overall risk.

Thus, this assessment was conducted of all I&M parks and the networks in which they reside to determine their relative rankings with respect to Pollutant Exposure, Ecosystem Sensitivity, Park Protection, and overall Summary Risk. Results were organized by network, and rankings were provided for each park and network.

Many of the variables that feed into this risk assessment are uncertain. They are constrained to a large degree by the need to cover the entire country. National-scale data that reflect various aspects of risk are scarce. In general, point source emissions data are more certain than nonpoint source data. Emissions and deposition data for S and NO_x are more certain than for NH_x. Wet deposition is more certain than dry or occult (cloud and fog) deposition. The relative sensitivities of various ecosystem types are not fully known.

Site or park-specific ecosystem data documenting effects of acidic deposition on soils, lichens, and aquatic biota were not considered here; rather, coarse-scale indicators that were available for all 272 parks were used to estimate risk more broadly. Thus, the risk rankings developed for this project should be considered as first approximations of true risk. Confidence in the rankings will increase as scientific knowledge regarding Pollutant Exposure and inherent Ecosystem Sensitivity improve, and also as national-scale datasets that shed light on these issues become available and are depicted at finer scales. This project should be considered only a first step in that process.

2.1 National Mapping Approach

The extent to which resources within a given national park are exposed to atmospheric S and N pollution is an elusive concept. Atmospheric deposition patterns, to the extent that they are known, are related to regional emissions, especially emissions from the areas that are generally upwind of the sensitive resources. Thus, the pattern in local to regional emissions can serve as a coarse surrogate for deposition exposure. Wet deposition is measured at many locations throughout the lower 48 states, but only at five NADP/NTN sites in Alaska, and not at all in the Pacific Islands. Overall, knowledge of regional patterns in deposition is incomplete and uncertain. The suite of wet deposition monitors is relatively dense, with good spatial coverage in the East but sparse coverage in the West. Dry deposition is monitored at fewer locations and was modeled spatially for this project using the atmospheric transport model CMAQ.

Two sets of maps are presented in each network section to illustrate the broad regional-to-national patterns observed for S and N emissions (Maps A and B) and deposition (Maps C and D). These national maps provide context for network and park-specific maps and data found in subsequent sections of this report. Map A illustrates patterns in total S emissions, expressed by county, in units of tons of S emitted into the atmosphere per square mile per year (tons/mi^2/yr). Map B illustrates patterns in total N emissions, expressed by county, in units of tons of N emitted into the atmosphere per square mile per year (tons/mi^2/yr). Total emissions are comprised of point, nonpoint, and mobile emission sources. This information is based on National Emissions Inventory (NEI) data from EPA for the year 2002 (http://www.epa.gov/ttnchie1/net/2002inventory.html).

Total S emissions showed a broad gradient from west to east (Map A). Emissions were low throughout most of the West, less than 1 ton/mi^2/yr. Emissions were higher throughout much of the midwestern and eastern United States, largely associated with coal-fired power plants. Counties that emitted more than 100 tons/mi^2/yr were relatively rare, but did occur, mainly in the Ohio Valley and the mid-Atlantic region.

In general, total N emissions also tended to be relatively low (less than about 5 tons/mi^2/yr) throughout much of the western United States, but above that level throughout much of the eastern United States. Relatively high N emissions levels (greater than 20 tons/mi^2/yr) occurred at scattered locations throughout the eastern United States and at a few locations in the West, primarily in and around Los Angeles and San Francisco. Counties that had in excess of 50 tons/mi^2/yr of N emissions were relatively rare.

Map C shows patterns in total S deposition in units of kilograms of S deposited to the Earth surface per hectare per year (kg S/ha/yr). Map D illustrates patterns in total N deposition in units of kilograms of N deposited to the Earth surface per hectare per year (kg N/ha/yr). The information for Maps C and D was derived by adding estimates of wet and dry deposition. Wet deposition was interpolated by J. Grimm (unpublished data) for the eastern United States from NADP measurements, with elevation correction to account for orographic effects (cf., Grimm and Lynch 1997). Wet deposition was modeled for the western United States using the CMAQ model (Robin Dennis, U.S. EPA, pers. comm., 2009) at 36-km resolution. Dry deposition was modeled using CMAQ for the western United States at 36-km resolution and for the eastern United States at 12-km resolution. Again, the CMAQ datasets were provided by Robin Dennis. NADP measurements were constructed as three-year averages centered on the year 2002. CMAQ simulations in all cases were for the year 2002, the most recent available year on a national basis. CMAQ estimates are periodically updated and refined by EPA.

Generally speaking, based on these estimates of wet plus dry S and N deposition, broad patterns in atmospheric deposition (Maps C and D) matched the broad patterns in emissions shown in Maps A and B. Most of the western United States received less than 2 kg S deposition per hectare per year and less than 5 kg N deposition per hectare per year, although higher values were seen in some areas, most particularly for N in parts of California, Washington, and the Front Range of Colorado. Broad areas in the eastern United States were estimated to receive more than 10 kg S/ha/yr and 10 kg N/ha/yr, and some locations appeared to receive considerably more than those amounts. As noted in previous sections of this report, total S and N deposition

may be significantly underestimated in areas that receive large amounts of deposition through clouds or fog.

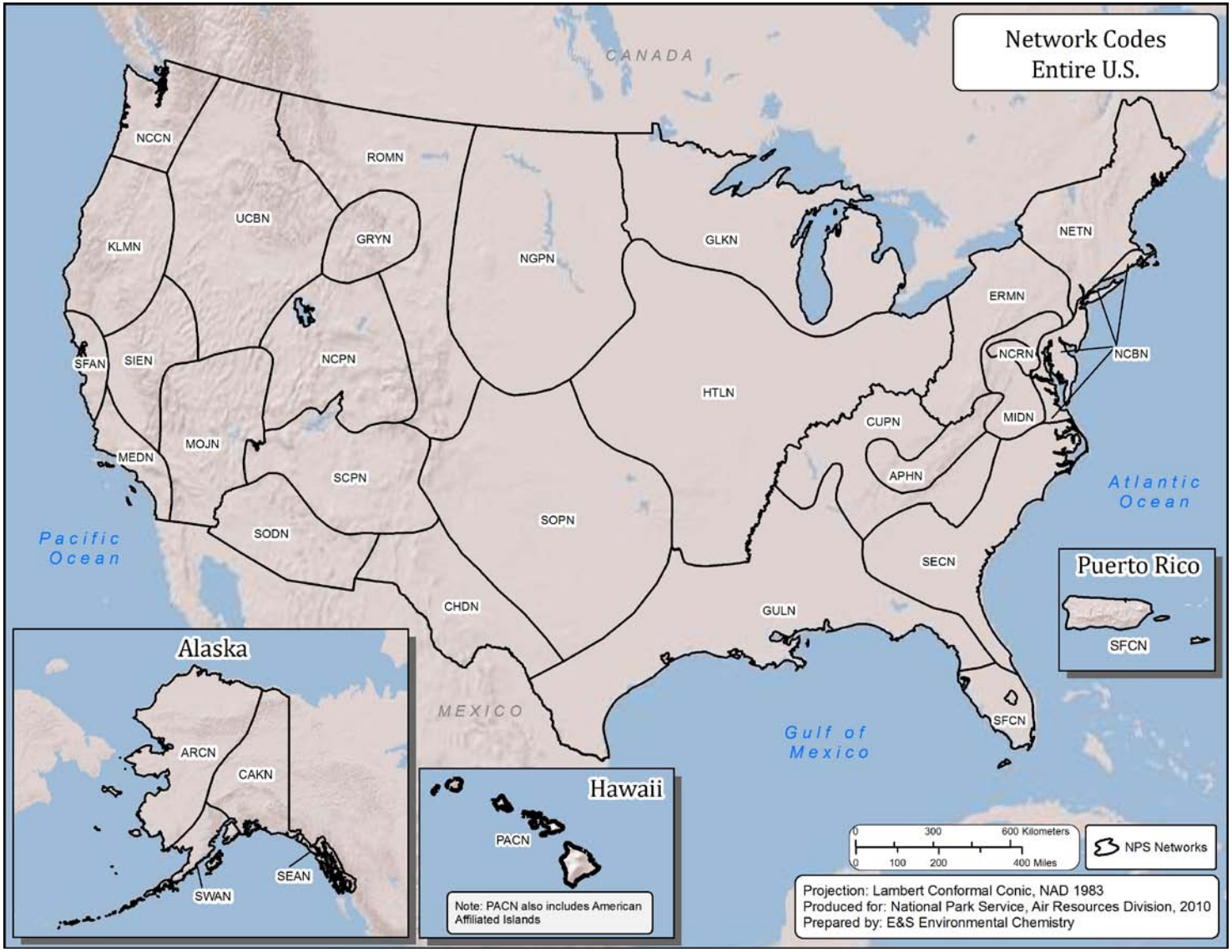
2.2 Network Mapping Approach

For each of the 32 I&M networks shown in Map 6, a series of maps is presented at the network scale to depict three themes, or aspects of: 1) S and N Pollutant Exposure, 2) inherent Ecosystem Sensitivity to acidification effects, and 3) the degree of special Park Protection against potential air pollution effects afforded to lands within that network. Each is described below.

2.2.1 Pollutant Exposure

The Pollutant Exposure variables represent various aspects of probable Pollutant Exposure, recently and in the future. There are eight Pollutant Exposure variables, listed in Table 2. Each of the Pollutant Exposure variables, and its associated data source(s), has uncertainty associated with it. In combination, these data provided an indication of relative levels of S and N emissions and deposition in and around the parks that occur within that network. The map labeling is consistent from network to network. For example, Maps E and F in each network depict county-level emissions data for S and N, respectively; Maps G and H in each network depict point sources; and so on. If there were no data available within a given network, the map is not included; subsequent maps are not relettered, but rather maintain the same letter designation for all networks.

Total S and N emissions are mapped by county in each network for the year 2002 and depicted in Maps E and F. These are the same emissions data that are shown for the nation in Maps A and B. The locations of individual point sources of S and both oxidized and reduced N compounds are shown, for all point sources included in the 2002 NEI database, in Maps G and H. Urban centers having populations greater than 10,000 people are shown in Map I. Urban populations are based on U.S. Census data for the year 2000. Urban centers constitute probable locations of both point and nonpoint pollutant sources, including motor vehicles, industry, equipment, and other stationary and mobile sources of emissions. Total S and N deposition in and around the network are depicted in Maps J and K, using the same sources of wet and dry deposition as depicted for the national coverage shown in Maps C and D. Finally, land cover data from the 2002 National Land Cover Dataset (NLCD) (http://www.mrlc.gov/nlcd_multizone_map.php) were mapped for each network (Map L) to provide an indication of where agricultural and developed lands (both probable sources of N, and to a lesser degree S, emissions) are located within and in proximity to each network. For all of these Pollutant Exposure maps, data are shown for the network itself, plus surrounding areas. These data are important from the perspective of emissions and deposition within the network. They are also important from the perspective of emissions that occur outside the network, but that might be transported to the network, and more specifically to the national parks, by the prevailing winds. Weather systems in the continental United States generally trend from west to east. Nevertheless, wind patterns are not fixed and national parks can receive Pollutant Exposure from emissions sources that occur in any direction from the park.



Map 6. Locations of I&M networks. The network names associated with the four-letter identification codes are given in Table 1.

Table 1. List of Inventory and Monitoring networks and associated network codes.

Network Name	Network Code
Appalachian Highlands	APHN
Arctic	ARCN
Central Alaska	CAKN
Chihuahuan Desert	CHDN
Cumberland Piedmont	CUPN
Eastern Rivers and Mountains	ERMN
Great Lakes	GLKN
Greater Yellowstone	GRYN
Gulf Coast	GULN
Heartland	HTLN
Klamath	KLMN
Mediterranean Coast	MEDN
Mid Atlantic	MIDN
Mojave Desert	MOJN
National Capital Region	NCRN
North Coast and Cascades	NCCN
Northeast Coastal and Barrier	NCBN
Northeast Temperate	NETN
Northern Colorado Plateau	NCPN
Northern Great Plains	NGPN
Pacific Island	PACN
Rocky Mountain	ROMN
San Francisco Bay Area	SFAN
Sierra Nevada	SIEN
Sonoran Desert	SODN
South Florida Caribbean	SFCN
Southeast Alaska	SEAN
Southeast Coast	SECN
Southern Colorado Plateau	SCPN
Southern Plains	SOPN
Southwest Alaska	SWAN
Upper Columbia Basin	UCBN

Table 2. Variables used to determine network rankings.

Variable	Method of Calculation
Pollutant Exposure Variables	
I. N emissions by county	Total county-level annual N emissions, as areally weighted average of lands within network, per unit area
II. S emissions by county	Total county-level annual S emissions, as areally weighted average of lands within network, per unit area
III. Human population within network	Total human population per unit area within network
IV. Human population within buffers	Total human population per unit area within 100-mile buffer around network
V. Percent developed land within network	Percent of land within network classified as developed area
VI. Percent agricultural within network	Percent of land within network classified as agricultural
VII. Average N deposition within parks	Areally weighted average total annual N deposition for all park lands that occur within the network
VIII. Average N deposition within parks	Areally weighted average total annual S deposition for all park lands that occur within the network
Ecosystem Sensitivity Variables	
IX. Percent sensitive vegetation types within parks	Amount of land within parks that occur within the network occupied by vegetation types expected to contain red spruce and/or sugar maple
X. Number of high-elevation lakes within parks	Number of high-elevation lakes found within parks that occur within the network
XI. Length of low-order streams	Total length of streams within park lands in network that are 1st, 2^{nd}, or 3^{rd} order
XII. Length of high-elevation streams	Total length of streams within park lands in network that occur at high elevation
XIII. Average slope	Areally weighted average slope of park lands within network
XIV. Acid-sensitive areas	Areally weighted average park lands within network that intersect with one or more of three regional studies that mapped acid sensitive areas in the United States
Park Protection Variables	
XV. Amount of lands in the park receiving special protection	Area of park lands within network designated as wilderness and/or Class I
XVI. Percent of lands in the park receiving special protection	Percent of park lands within network designated as wilderness and/or Class I
XVII. Percent of network in designated wilderness	Percent of all lands within network designated as wilderness
Summary Statistics	
XVIII. Pollutant exposure	Average of rankings for variables I through VIII

Table 2. Variables used to determine network rankings.	
Variable	**Method of Calculation**
XIX. Ecosystem sensitivity	Average of rankings for variables IX through XIV
XX. Park protection	Average of rankings for variables XV through XVII
XXI. Summary Risk of acidification effects	Average of rankings for variables XVIII through XX

2.2.2 Ecosystem Sensitivity

Acidification effects from acidic deposition to terrestrial ecosystems can potentially occur in any vegetative community. There likely exists a range of plant species sensitivity to acidity. Nevertheless, recent research suggests that some plant species and some kinds of streams and lakes in the United States tend to be more susceptible to such effects than others. In general, we expect the most sensitive tree species to include red spruce and sugar maple. Therefore, these are the plant species analyzed here. Inherent terrestrial Ecosystem Sensitivity to acidification effects is represented using the presence of terrestrial vegetation types known or suspected to contain red spruce and/or sugar maple trees. Red spruce and sugar maple only occur in a few of the larger I&M parks and their mapped distribution is difficult to see at the network scale. This vegetation is, therefore, mapped at the park, rather than the network, scale.

Vegetation data were collected from a variety of sources. The primary source was the NPS Vegetation Mapping Inventory/ USGS Vegetation Characterization Program (http://biology.usgs.gov/npsveg/). This inventory of the 272 I&M parks is on-going and not all parks have been completed. Secondarily, vegetation data generated through the U.S. Forest Service (USFS) LANDFIRE program were used for the remainder of the parks within the lower 48 states. For parks in Alaska, Pacific Islands, and Puerto Rico, sensitive vegetation types were identified from previous NPS surveys, USFS surveys, and NLCD data.

Acid-sensitive regions of the conterminous United States have previously been identified and mapped in various studies. For this NPS study, we used a compilation of three sources of mapped information on known areas of acid sensitivity: 1) EPA's Omernik and Powers (1983) surface water alkalinity map, 2) the Stoddard et al. (2003) report to EPA on the response of surface water chemistry to the Clean Air Act Amendments (CAAA) of 1990, and 3) the Southern Appalachian Mountains Initiative (SAMI) geological sensitivity mapping effort (Sullivan et al. 2007). Each is described below.

Omernik Alkalinity Map. Data for the Omernik sensitivity statistic were obtained from EPA's map entitled *Total Alkalinity of Surface Waters* (Omernik and Powers 1983). This is an important map coverage in that it was constructed using drainage water chemistry data gathered throughout the United States in association with information on geology, soils, vegetation, and topography. However, the coverage is only available as a map that cannot be georectified. The native projection of this nearly 30-year old data layer is unknown.

For this NPS study, national parks were evaluated to estimate from the Omernik and Powers (1983) map whether or not the park land contained surface water that might be expected to have

relatively low ANC (less than 100 µeq/L). Because of the problems with georectification, precise calculations could not be performed; rather, a visual examination was made to determine which parks appeared to overlap, at least in part, with the Omernik ANC < 100 µeq/L sensitivity category.

Stoddard Sensitive Regions. Delineations of acid-sensitive regions in the northern and eastern United States were obtained from the Stoddard et al. (2003) report entitled Response of Surface Water Chemistry to the Clean Air Act Amendments of 1990. Figure 2 from this report, showing acid-sensitive regions identified in the northern and eastern United States, was recreated using ArcGIS and Omernik level 2 ecoregions. The identified acid-sensitive ecoregions included portions of New England, Adirondack Mountains, Northern Appalachian Plateau, Ridge and Valley and Blue Ridge Provinces, and Upper Midwest. For this NPS study, I&M park lands were evaluated to estimate from the Stoddard et al. (2003) map which parks contained acid-sensitive areas.

SAMI Geologic Sensitivity Map. As part of the SAMI aquatic assessment, Sullivan et al. (2007) delineated the portions of the southern Appalachian Mountains that contained nearly all of the acidic and very low ANC (≤ 20 µeq/L) streams known to occur within the SAMI study domain. This classification was based on a combination of siliciclastic lithology (with a buffer to accommodate uncertainty in geologic boundary locations) and elevation. Parks that overlapped with the SAMI map of sensitive areas were identified.

Compilation of Data on Acid-Sensitive Regions. For the park rankings, all parks were identified that overlapped with one or more of the three regional mapping efforts identified above. Such parks were assigned a value of 1 for the Acid Sensitive Areas variable. Parks that did not overlap with any of these coverages were assigned a value of 0. Network rankings were calculated as areally weighted averages of all parks within the network that have at least some portion of the park falling within the low ANC category of the Acid Sensitive Areas variable.

Acid-sensitive drainage waters and watershed soils tend to occur on relatively steep terrain, often at high elevation. Acid-sensitive streams are most often low-order. Average watershed slopes of all 10-digit HUC watersheds within each park were calculated, and were mapped on Map M. High-elevation lakes and streams and first- through third-order streams are mapped at the park scale (see Section 2.3).

The average slope of parklands in each network (Map M) was depicted in order to help identify areas of high aquatic ecosystem sensitivity to acidification. Calculations were made for each network to indicate the presence of high-elevation lakes and streams, and the presence of low-order streams in parks that occur within the network. These data layers are re not shown on maps at the network scale because the majority of the high-elevation lakes are too small and the low-order and high-elevation stream networks are generally too dense to see at that scale. These map layers are shown, where important to the overall sensitivity of a given park, at the individual park scale.

Total N emissions are mapped by county in each network for the year 2002 and depicted in Map C. These are the same emissions data that are shown for the nation in Map A. The locations of individual point sources of both oxidized and reduced N compounds are shown, for all point sources included in the 2002 NEI database, in Map D. Urban centers having populations greater than 10,000 people are shown in Map E. Urban populations are based on U.S. Census data for the year 2000. Urban centers constitute probable locations of both point and nonpoint pollutant sources, including motor vehicles, industry, equipment, and other stationary and mobile sources of N emissions. Total N deposition in and around the network is depicted in Map F, using the same sources of wet and dry deposition as depicted for the national coverage shown in Map B. Finally, land cover data from the National Land Cover (NLCD) Dataset (http://www.mrlc.gov/nlcd_multizone_map.php) were mapped for each network to provide an indication of where agricultural and developed lands (both probable sources of N emissions) are located within and in proximity to each network.

For all of these N Pollutant Exposure maps, data are shown for the network itself, plus surrounding areas. These data are important from the perspective of emissions and deposition within the network. They are also important from the perspective of emissions that occur outside the network, but that might be transported to the network, and more specifically to the national parks, by the prevailing winds. Weather systems in the continental United States generally trend from west to east. Nevertheless, wind patterns are not fixed and national parks can receive N Pollutant Exposure from emissions sources that occur in any direction from the park.

Inherent terrestrial Ecosystem Sensitivity to nutrient N enrichment effects is represented using maps of the presence of certain terrestrial vegetation types (Map H). Nutrient enrichment effects from N deposition to terrestrial ecosystems can occur in any vegetative community. There will always be a range of plant species sensitivity to N addition. Some species will benefit from added N; other species will lose competitive advantage in response to N enrichment. This response pattern is expected in all plant community types. Similarly, it is possible, but not likely, that a lake in virtually any setting could be N-limited and sensitive to N input. However, recent research suggests that some plant community types and the algae in some lakes in the United States are more susceptible to such effects than others. Research indicates that the most sensitive terrestrial vegetation types include herbaceous arctic, alpine, meadow, and arid or semi-arid plant communities. Wetland plant communities have also been found to be relatively sensitive, based largely on research conducted in Europe. Therefore, these are the vegetation types mapped and analyzed here.

Vegetation data were collected from a variety of sources. The primary source was the NPS Vegetation Mapping Inventory/ USGS Vegetation Characterization Program (http://biology.usgs.gov/npsveg/). This inventory of the 272 I&M parks is on-going and not all parks have been completed. Secondarily, vegetation data generated through the U.S. Forest Service (USFS) LANDFIRE program were used for the remainder of the parks within the lower 48 states. The National Wetland Inventory (NWI) dataset was also used as a secondary source for wetland data. For parks in Alaska, Pacific Islands, and Puerto Rico, sensitive vegetation types were identified from previous NPS surveys, USFS surveys, and NLCD data. The source of the vegetation coverage data used for each I&M park is given in Appendix A. Some tree species, especially red spruce and sugar maple, are known to be highly sensitive to N and S deposition

because of acidification, rather than nutrient enrichment, effects. These sensitivities are addressed in a separate report.

In general, high-elevation lakes are not mapped at the network scale. This is because the high-elevation lakes tend to be too small to be seen at that scale. Rather, where high-elevation lakes are numerous in an I&M park, they are typically mapped at the park scale (discussed below in the Park Mapping Approach section).

The degree of special protection afforded to national parks was evaluated on the basis of land classification as Class I areas and as designated wilderness. Class I and wilderness areas receive the highest levels of protection under the CAA and the Wilderness Act, respectively. The 1977 Clean Air Act Amendments (CAAA) outlined special protections for Class I areas relative to adverse impacts on Air Quality Related Values (AQRVs). The latter include flora and bodies of water that could potentially be damaged by air pollution and atmospheric deposition. Congress also delegated to federal land managers an affirmative responsibility to protect AQRVs in Class I areas. The 1990 CAAA further strengthened this responsibility and special protections. The Wilderness Act of 1964 established the National Wilderness Preservation System and requires protection of the earth and its community of life at a level of natural conditions. Both NPS Class 1 and Wilderness areas (all jurisdictions) are mapped for each network, and depicted on Map I.

2.2.3 Park Protection

The degree of special protection afforded to national parks was evaluated on the basis of land classification as Class I areas and as designated wilderness. Class I and wilderness areas receive the highest levels of protection under the CAA and the Wilderness Act. The 1977 CAAA outlined special protections for Class I areas relative to adverse impacts on AQRVs. The latter include flora and bodies of water that could potentially be damaged by air pollution and atmospheric deposition. Congress also delegated to federal land managers an affirmative responsibility to protect AQRVs in Class I areas. The 1990 CAAA further strengthened this responsibility and special protections. The Wilderness Act of 1964 established the National Wilderness Preservation System and requires protection of the earth and its community of life at a level of natural conditions. Both NPS Class 1 and wilderness areas (all jurisdictions) were mapped for each network, and depicted on Map N.

2.3 Park Mapping Approach

For networks that include some of the larger national parks and some of the parks that have been more thoroughly studied with respect to effects from acidic deposition, one or more park-specific maps is also provided. These maps show the locations of vegetation types that generally contain the tree species thought to be most responsive to acidification effects and/or the locations of high-elevation and low-order streams and high-elevation lakes that may be more likely to be acid-sensitive than many lower-elevation, down-gradient streams and lakes. Each of these data layers is more visible on the park maps, which show only a small fraction of the overall land area within the network. Sensitive vegetation types often occur as small patches, which can be difficult to see at the scale of the network. Acid-sensitive high-elevation lakes are often, but not always, small (i.e., less than about 100 hectares in area).

For high-elevation lake and stream mapping, areas were identified as high elevation using the following criterion. For each network, the elevation above which 15% of the network area exists was determined. Any lake or stream within a park that occurs above this elevation was considered to exist at "high elevation." Hydrography data were obtained from the National Hydrography Dataset (NHD) at medium resolution (approximately 1:100K) for all parks except those in Alaska, where only high-resolution (approximately 1:24K) NHD data were available. The number of lakes and length of stream that occur at high elevation within each park was extracted and tabulated for each network. Only a relatively small number of parks contain high-elevation lakes. There are more parks that contain high-elevation streams..

2.4 Calculation of Network and Park Rankings

The I&M networks are listed in Table 1, along with the four-letter codes used to identify them. These codes are used in subsequent tables and figures for network identification. Network locations are shown in Map 6. Eight variables were calculated to represent various aspects of Pollutant Exposure within the 32 park networks (Table 2). Each Pollutant Exposure variable reflects one or more aspects of atmospheric emissions in and/or near the network or the best available estimate of the general patterns of deposition in and around the parks that occur in that network. Each of the listed variables was calculated for each network. Networks were then ranked for each variable, from the network showing the lowest Pollutant Exposure (lowest rank) to the network showing the highest Pollutant Exposure (highest rank). For cases where more than one network had the same pollutant exposure for a particular variable, an average of these network ranks was assigned to each. For instance, the Arctic and the Southeast Alaska networks both had 0% Agriculture, and were assigned network rank orders of 1 and 2; because neither network is more or less sensitive than the other for this particular variable, the average rank of 1.5 was assigned to each network.

These eight variable-specific rankings were then averaged to yield an overall Pollutant Exposure ranking for each of the 32 networks, where lower numbers (near 1) reflect lower Pollutant Exposure and higher numbers (near 32) reflect higher Pollutant Exposure. Network ranks were categorized by color-coded quintiles, based on the overall range of rankings for Pollutant Exposure. Results of this summary statistic are graphed for each network. Results are ordered from left to right on the graph to reflect decreasing Pollutant Exposure ranking, and are color-coded according to quintile from the lowest quintile (the 20% of networks that received the lowest Pollutant Exposure ranking) to the highest quintile (highest 20% of network rankings). Warm colors (red, orange) reflect higher risk; cool colors (green, blue) reflect lower risk. The following quintile categories were reported: (1) less than 20^{th} percentile as blue, or Very Low risk; (2) 20^{th} to 40^{th} percentile as green, or Low risk; (3) 40^{th} to 60^{th} percentile as Yellow, or Moderate risk; (4) 60^{th} to 80^{th} percentile as orange, or High risk; (5) 80^{th} to 100^{th} percentile as red, or Very High risk.

Network rankings were calculated in generally the same manner for the other two themes: Ecosystem Sensitivity and level of Park Protection. Ecosystem Sensitivity was represented by six variables, and Park Protection was represented by three variables (Table 2). The former was based on the known distribution of acid-sensitive resources, average land slope, and the abundance of surface water and vegetative types expected to be most sensitive to acidification. The variable that represented the known location of acid-sensitive waters and geology received a

disproportionate (x 3) weight in calculating the average Ecosystem Sensitivity rankings. This was because conditions such as steep slope, high elevation, and low stream order only tend to be associated with acid sensitive drainage waters where geology is base poor. Regions of base-poor geology generally contain more acid-sensitive waters than similar areas of base-rich geology. The Park Protection variable was based on designation as wilderness and Class I areas. Finally, an overall risk of acidification effects was calculated based on the average of the quintile rankings for the three themes discussed above.

Individual scores that formed the basis for the risk rankings are tabulated in Table 3. Results of this Summary Risk assessment are graphed, with networks having highest risk shown on the left, and networks having lowest risk shown on the right.

Rankings for the 271 individual I&M parks (plus the Appalachian Trail corridor, which is addressed within the section on the Appalachian Highlands Network) were calculated using the variables given in Table 4. Tied park rankings were treated as described for tied network rankings. As for the network rankings, park rankings were calculated individually for Pollutant Exposure, Ecosystem Sensitivity, and Park Protection metrics. Results of those rankings, summarized by quintile, are listed in Appendix A and are summarized in tabular form in each of the individual network sections of the report. Average scores for each theme for the 79 larger I&M parks (those larger than 100 square miles) are graphed and mapped.

The average of the quintile ranks (1.0–5.0) for Pollutant Exposure, Ecosystem Sensitivity, and Park Protection was calculated for each network and for each park. Based on this average, each was classified into one of five overall risk categories. Both the network and the park Summery Risk categories were assigned as follows: 1.0–1.99 (Very Low), 2.0–2.49 (Low), 2.5–3.49 (Moderate), 3.5–4.24 (High), 4.25–5 (Very High). As for the network rankings, park rankings were calculated individually for N Pollutant Exposure, Ecosystem Sensitivity, and Park Protection metrics. Results of those rankings, summarized by quintile, are listed in Appendix B and are summarized in tabular form in each of the individual network sections of the report. Average scores for each metric and results of the overall park-specific Summary Risk assessment for the 79 larger I&M parks (those larger than 100 square miles) are graphed and mapped in the Results section below.

Table 3. Acidification risk rankings for quantitative variables calculated for each of the 32 I&M park networks.

Network Name	Variable Ranking[1]																
	Pollutant Exposure Variables								Ecosystem Sensitivity Variables						Park Protection Variables		
	I	II	III	IV	V	VI	VII[2]	VIII[2]	IX	X	XI	XII	XIII	XIV	XV	XVI	XVII
Appalachian Highlands	20	25	19	23	20	20	26	27	31	27	24	28	28	32	18	20	13
Arctic	3	3	1	1	1	1.5	ND	ND	11	10.5	ND	32	9	ND	31	17	26
Central Alaska	4	4	4	2	4	4	ND	ND	11	10.5	ND	31	12	ND	32	18	29
Chihuahuan Desert	7	7	9	11	7	6	24	13	11	10.5	25	21	14	1	21	24	10
Cumberland Piedmont	25	29	20	19	27	27	29	29	30	23.5	10	18	17	22	11	12	8
Eastern Rivers and Mountains	26	30	24	29	25	22	27	31	28	10.5	14	13	25	30	2.5	2.5	7
Great Lakes	22	22	22	15	23	30	18	19	26	23.5	19	7	5	27	19	19	14
Greater Yellowstone	5	11	6	5	6	13	13	12	11	29	30	22	20	25	27	29	27
Gulf Coast	21	23	18	17	17	23	22	24	24	10.5	15	14	3	1	6	6	4
Heartland	24	26	17	18	18	32	28	25	25	23.5	18	15	18	1	8	9	5
Klamath	12	6	12	20	14	12	11	14	11	28	17	23	21	20	17	27	20
Mediterranean Coast	29	18	30	25	31	14	17	20	11	10.5	20	2.5	23	1	2.5	2.5	22
Mid Atlantic	27	28	26	30	22	28	30	28	29	10.5	12	20	27	26	14	26	11
Mojave Desert	11	10	14	21	8	7	10	6	11	10.5	32	24	19	1	29	14	28
National Capital Region	31	32	31	26	30	29	31	32	27	10.5	7	6	11	24	2.5	2.5	1
North Coast and Cascades	19	16	21	8	19	11	14	17	11	31	28	26	32	23	26	31	30
Northeast Coastal and Barrier	32	31	32	31	32	26	32	30	23	10.5	5	2.5	4	21	5	5	2
Northeast Temperate	18	19	27	32	21	15	19	23	32	10.5	6	2.5	16	28	9	22	9
Northern Colorado Plateau	9	13	10	7	9	9	8	9	11	23.5	26	11	26	1	20	21	16
Northern Great Plains	14	14	5	9	13	31	25	16	22	23.5	23	19	8	1	13	11	3
Pacific Island	16	21	25	28	26	10	ND	ND	11	10.5	8	9	10	ND	16	28	19
Rocky Mountain	8	12	11	6	11	18	15	15	11	30	27	27	30	29	22	30	18
San Francisco Bay Area	30	20	29	16	28	19	16	18	11	10.5	16	10	22	1	12	10	17
Sierra Nevada	15	8	15	24	15	17	12	11	11	32	29	30	31	31	25	32	25
Sonoran Desert	13	9	16	13	12	8	6	10	11	10.5	21	16	29	1	15	25	24

Table 3. Acidification risk rankings for quantitative variables calculated for each of the 32 I&M park networks.

Network Name	Variable Ranking[1]																
	Pollutant Exposure Variables								Ecosystem Sensitivity Variables						Park Protection Variables		
	I	II	III	IV	V	VI	VII[2]	VIII[2]	IX	X	XI	XII	XIII	XIV	XV	XVI	XVII
South Florida Caribbean	28	27	28	27	29	24	20	21	11	10.5	22	2.5	1	1	24	15	23
Southeast Alaska	1	2	3	3	3	1.5	ND	ND	11	10.5	ND	2.5	15	ND	28	23	32
Southeast Coast	23	24	23	22	24	21	23	26	11	10.5	13	17	2	1	7	8	12
Southern Colorado Plateau	10	15	8	10	5	5	7	8	11	23.5	31	25	24	1	23	13	15
Southern Plains	17	17	13	14	16	25	21	22	11	10.5	9	12	7	1	2.5	2.5	6
Southwest Alaska	2	1	2	4	2	3	ND	ND	11	10.5	ND	29	13	ND	30	16	31
Upper Columbia Basin	6	5	7	12	10	16	9	7	11	10.5	11	8	6	1	10	7	21

[1] The rankings range from the lowest network to the highest network, thus, a low value reflects low risk. Variable Roman numbers given at the top of the columns are described in Table 2. Tied ranks are averaged.

[2] Deposition data are not available on a regional basis for Alaska. However, based on emissions data and probable sources, deposition in these networks is expected to be very low.

ND = No data

Table 4. Variables to determine I&M park rankings.

Variable	Method of Calculation
Nitrogen Pollutant Exposure Variables	
I. Average N deposition	Average total annual N deposition for all lands within the park
II. Average S deposition	Average total annual S deposition for all lands within the park
III. N emissions by county	Total county-level annual N emissions, as areally weighted average of all counties bordering on the park and within 100 miles of the park boundary, per unit area
IV. S emissions by county	Total county-level annual S emissions, as areally weighted average of all counties bordering on the park and within 100 miles of the park boundary, per unit area
Ecosystem Sensitivity Variables	
V. Percent sensitive vegetation types	Amount of land within parks that occur within the network occupied by vegetation types expected to contain red spruce and/or sugar maple
VI. Number of high-elevation lakes	Number of high-elevation lakes within the park
VII. Length of low-order streams	Total length of streams within park that are 1^{st}, 2^{nd}, 3^{rd} order
VIII. Length of high-elevation streams	Total length of streams within park that occur at high elevation
IX. Average slope	Average slope of lands within park
X. Sensitive areas[1]	Occurrence of more than 5% of park land within one or more of three regional studies that mapped acid sensitive areas in the United States
Park Protection Variables	
V. Amount of lands in the park receiving special protection	Area of park designated as wilderness and/or Class I
VI. Percent of lands in the park receiving special protection	Percent of park designated as wilderness and/or Class I
Summary Statistics	
XIII. Pollutant Exposure	Average of rankings for variables I through IV
XIV. Ecosystem Sensitivity	Average of rankings for variables V through X
XV. Park Protection	Average of rankings for variables XI and XII
XVI. Summary Risk of nutrient-N enrichment	Average of rankings for variables XIII through XV

[1] This variable received a weight that was three times higher than other Ecosystem Sensitivity variables.

3. Results

3.1 Overall Ranking of Networks and Parks

3.1.1 Networks

The calculated values of the rankings for the Pollutant Exposure metrics across the 32 networks, shown for each variable individually in Table 3, are depicted for the Pollutant Exposure theme in Figure 1. The two networks having the highest average rankings for the eight Pollutant Exposure variables (Northeast Coastal and Barrier Network, National Capital Region Network) are shown on the left side of the graph as the tallest bars. These networks had average ranks for the eight Pollutant Exposure variables approximately equal to 30 out of a maximum 32. In other words, these networks had consistently high rankings for the eight variables that were used to indicate S and N Pollutant Exposure. The four networks on the far right side of the graph (shortest bars) all showed an average Pollutant Exposure ranking that was less than 4. This means that each of these four networks was consistently ranked low for the S and N Pollutant Exposure variables. Not surprisingly, these are the four networks in Alaska, where atmospheric emissions of S and N are very low at most locations. Note that regional estimates of acidic deposition are not available for Alaska. Although wet deposition is measured at five sites in Alaska, coverage is not broad enough to interpolate wet deposition over the region, and dry deposition estimates are not available from CMAQ. Wet deposition of both S and N at the five Alaska sites is very low. Because of the unavailability of regional data, the average of the Pollutant Exposure rankings for networks in Alaska was calculated for only six, rather than all eight, variables listed in Table 2. Also, note that these low rankings for the Alaskan networks do not necessarily indicate that S and/or N emissions are universally low throughout Alaska. Rather, they indicate that emissions (and associated deposition) are generally low throughout the networks in this region. There may, in fact, be isolated "hot spots" of relatively high emissions and deposition.

Rankings for network-specific Ecosystem Sensitivity and Park Protection metrics are presented in the same manner as the Pollutant Exposure metric. In the case of Ecosystem Sensitivity, the average is calculated for six variables that reflect known geographic areas of acid sensitivity, land slope, likely presence of known acid-sensitive tree species, presence of high-elevation lakes and streams, and presence of low-order streams. For Park Protection, the average is calculated for three variables: area of parkland classified as Class I and/or wilderness, percent of parkland classified as Class I and/or wilderness, and percent of network designated as wilderness. The calculated averages for the rankings of Ecosystem Sensitivity and Park Protection are given in Figures 2 and 3, respectively.

The eight networks that scored highest (on left side of the graphic) for Ecosystem Sensitivity were mostly mountainous networks in the contiguous United States: Appalachian Highlands, Sierra Nevada, Rocky Mountains, North Coast and Cascades, Greater Yellowstone, Mid-Atlantic, Cumberland Piedmont, and Eastern Rivers and Mountains. The networks that scored highest for Park Protection were all western mountain and Alaskan networks. Two desert networks (Mojave Desert, Sonoran Desert) were also ranked fairly high for this metric.

The calculated rankings, by network, for each of the three themes are shown in Maps 7–9. Networks are color coded on the maps from a ranking of Very Low (lowest quintile; blue) to Very High (highest quintile; red) for each theme.

The network Summary Risk Ranking (Figure 4, Map 10) was calculated as the average of the three theme quintile rankings described above. The scale on this graph ranges from a theoretical minimum of 1.0 (average of three quintiles, where each rank is the lowest for all variables) to a theoretical maximum of 5 (average of quintiles, where each was highest for all variables). In fact, the calculated averages ranged from about 1.3 to 4.4. The networks that showed the highest calculated Summary Risk included four western mountain networks (North Coast and Cascades, Sierra Nevada, Rocky Mountain, and Greater Yellowstone), four networks in the eastern United States (Mid-Atlantic, Appalachian Highlands, Cumberland Piedmont, and Eastern Rivers and Mountains), and the Great Lakes Network.

Overall scores among networks for Summary Risk did not exhibit a wide distribution of values. There were many cases where networks showing high pollution exposure also showed low Ecosystem Sensitivity, and vice versa. The end result was that the network Summary Risk ranking, which was calculated based on the individual theme ranks, did not show large differences among networks, especially within the middle portion of the distribution. Rankings did show somewhat greater divergence at the extremes of the distribution. Thus, there is somewhat more confidence in concluding that the Summary Risk rankings for the Mid-Atlantic, North Coast and Cascades, and Sierra Nevada are indeed Very High than in concluding that the Eastern Rivers and Mountains Network (ranked High) is actually at greater Summary Risk for acidification damage than the Northeast Coastal and Barrier Network (ranked Low; Table 5, Figure 4).

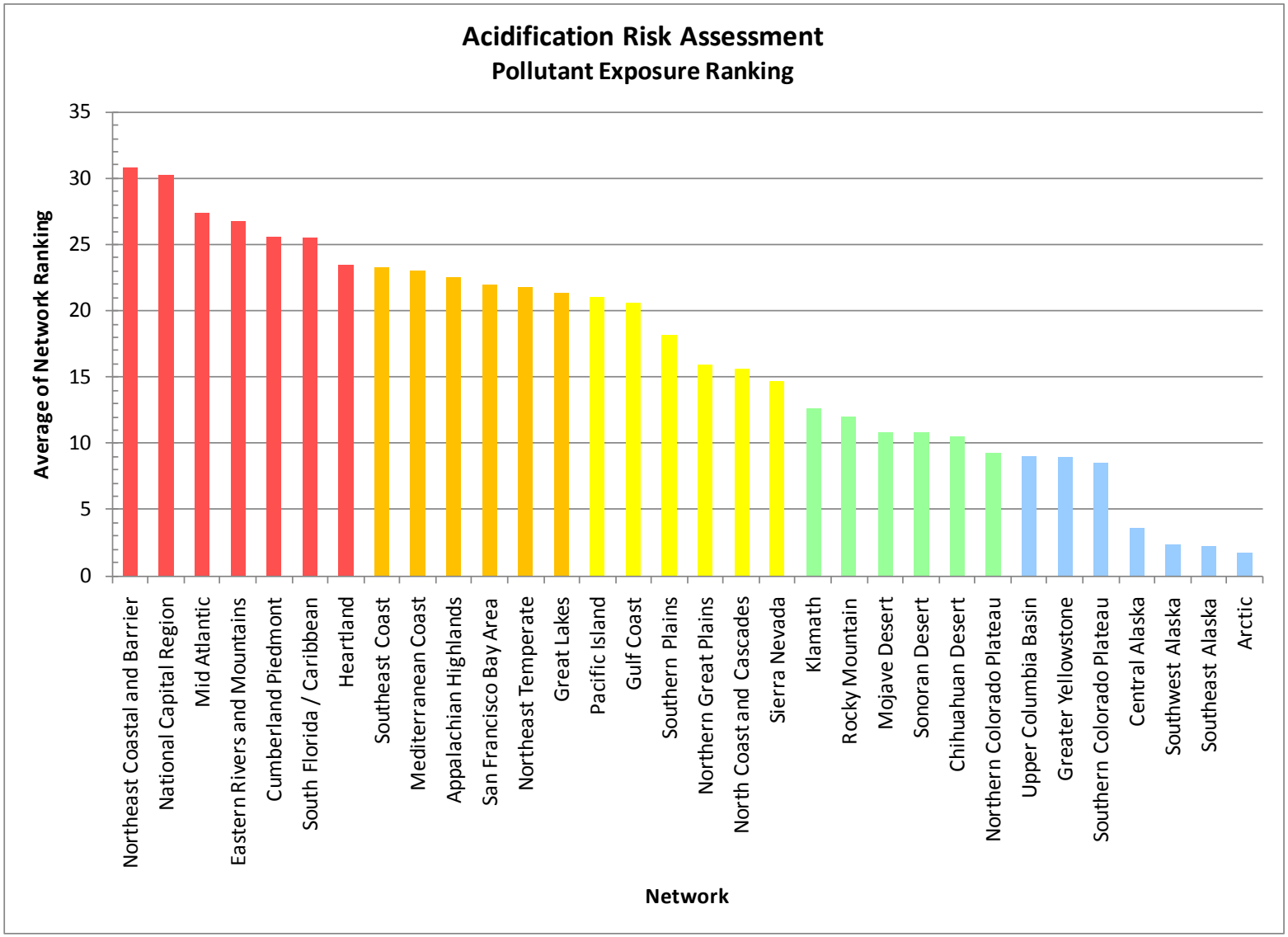


Figure 1. Calculated S and N Pollutant Exposure ranking for each of the 32 I&M networks. Networks are color coded by quintile.

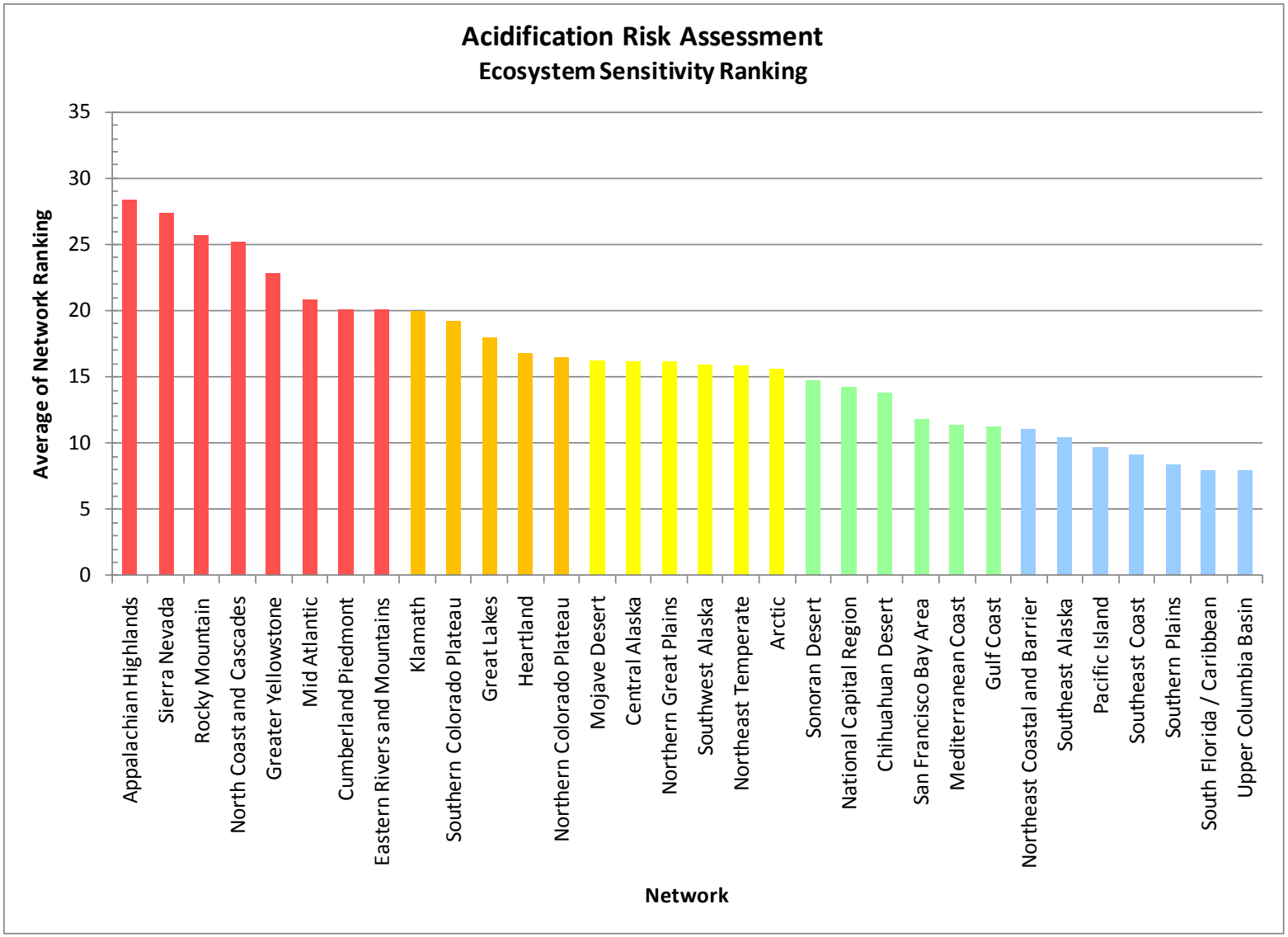


Figure 2. Calculated Ecosystem Sensitivity ranking for each of the 32 I&M networks. Networks are color coded by quintile.

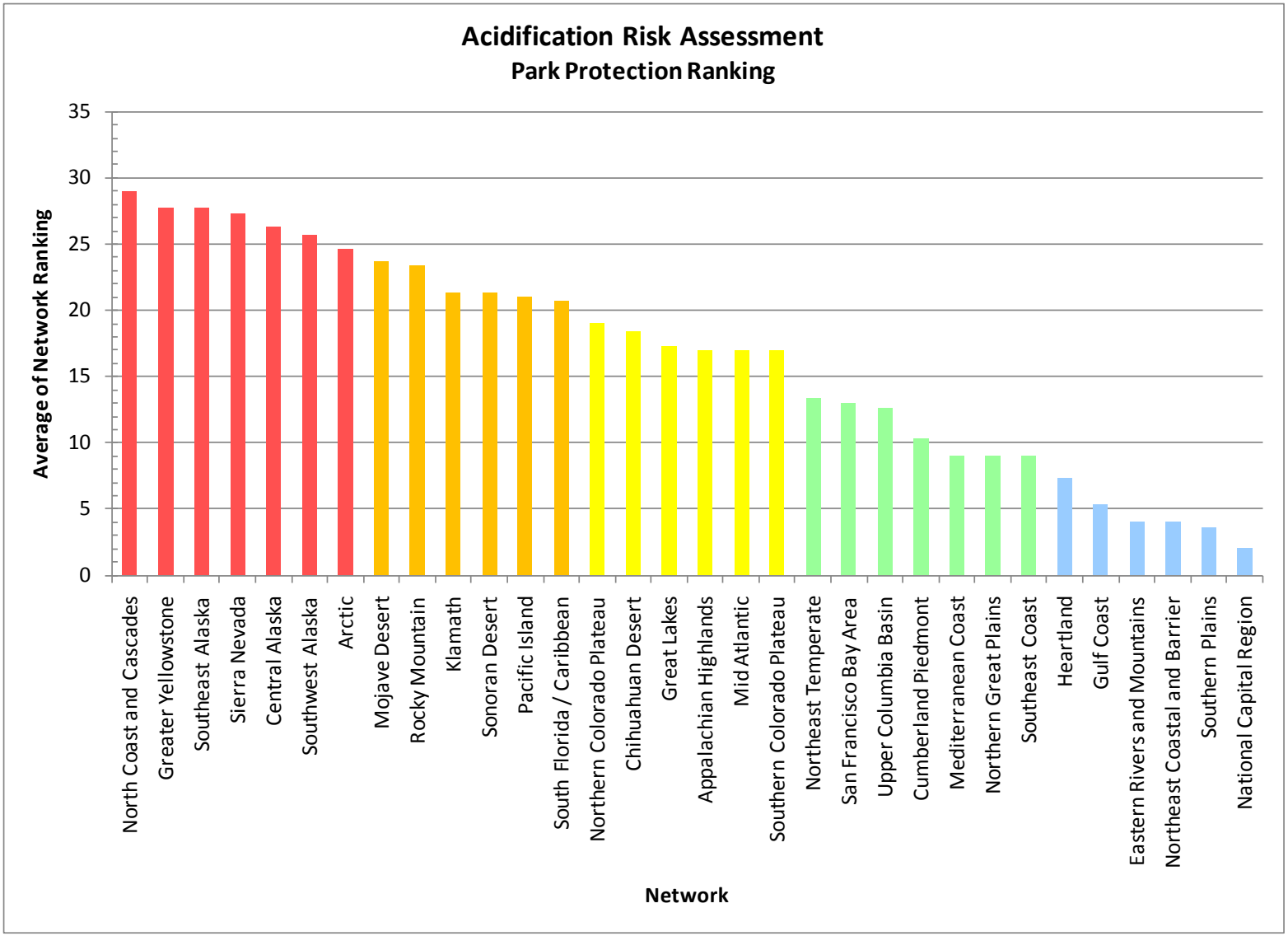


Figure 3. Calculated Park Protection ranking for each of the 32 I&M networks. Networks are color coded by quintile.

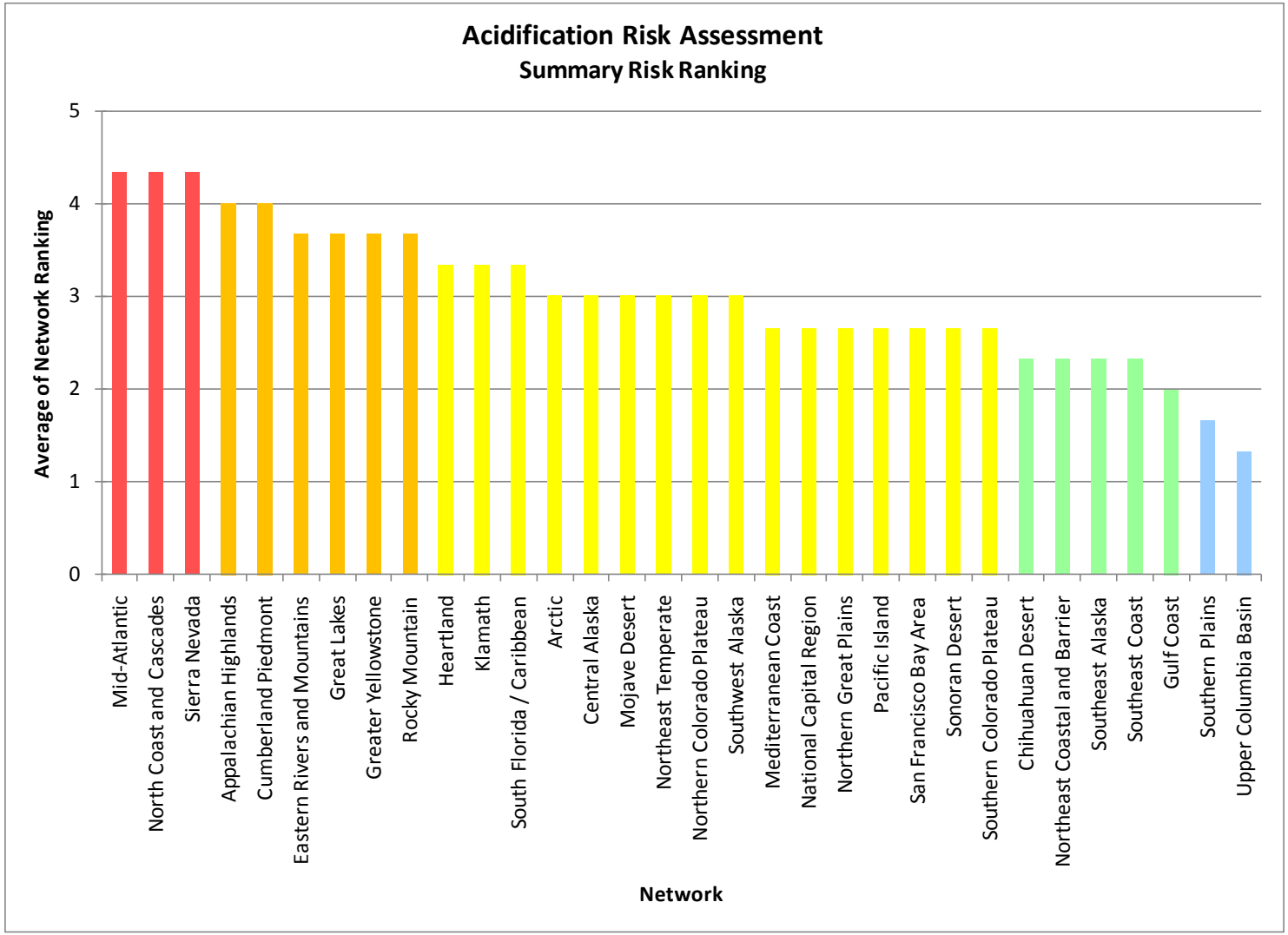
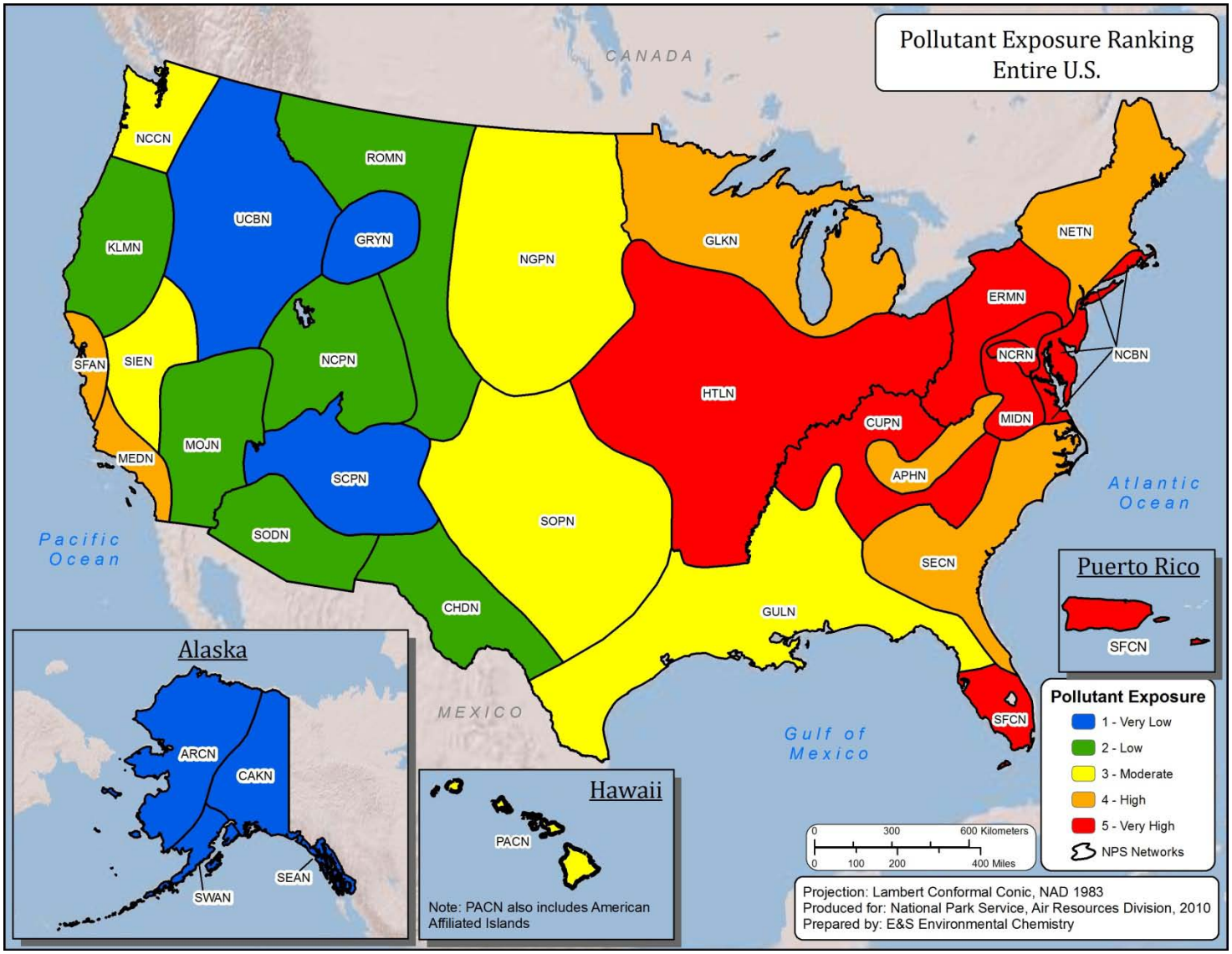
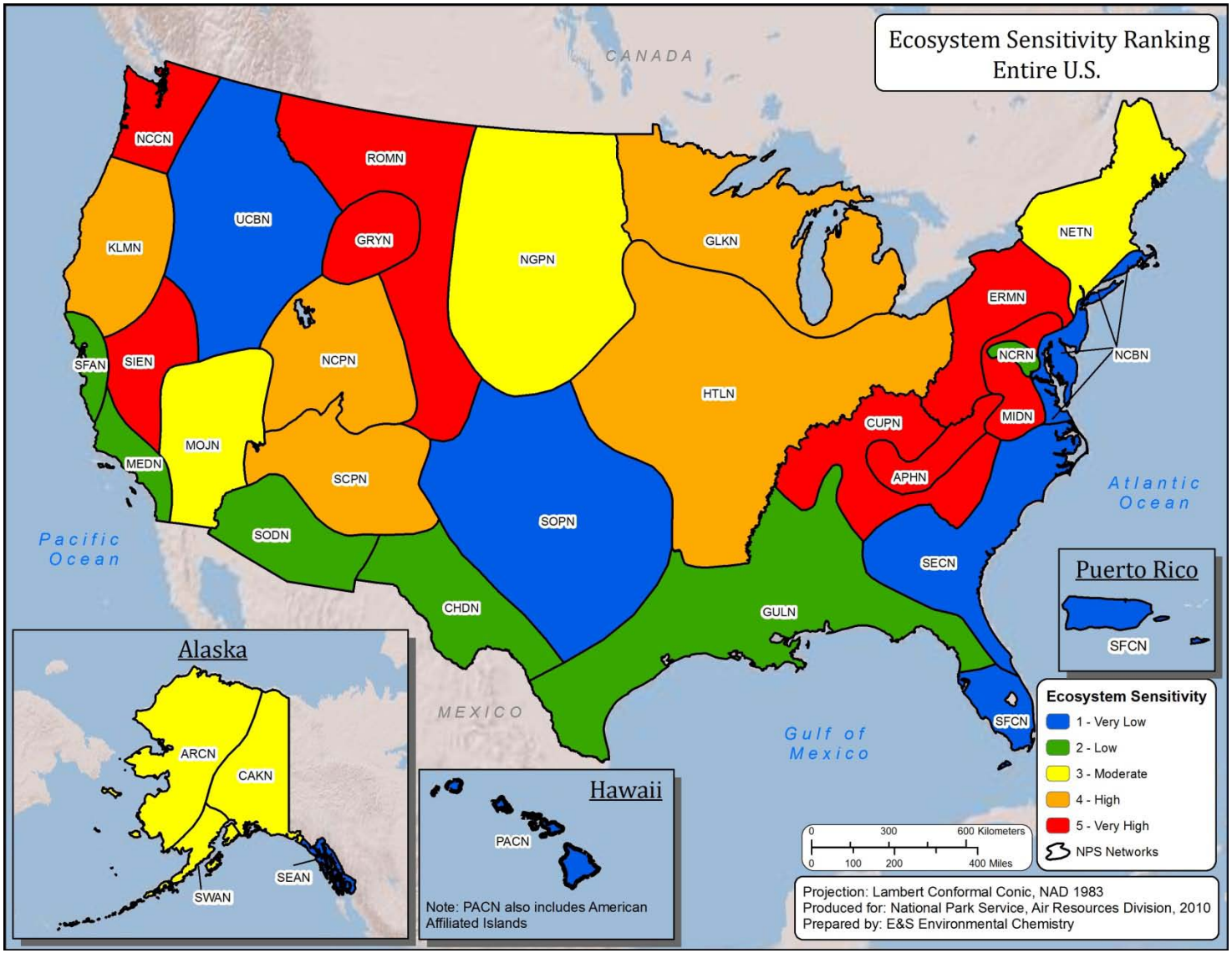


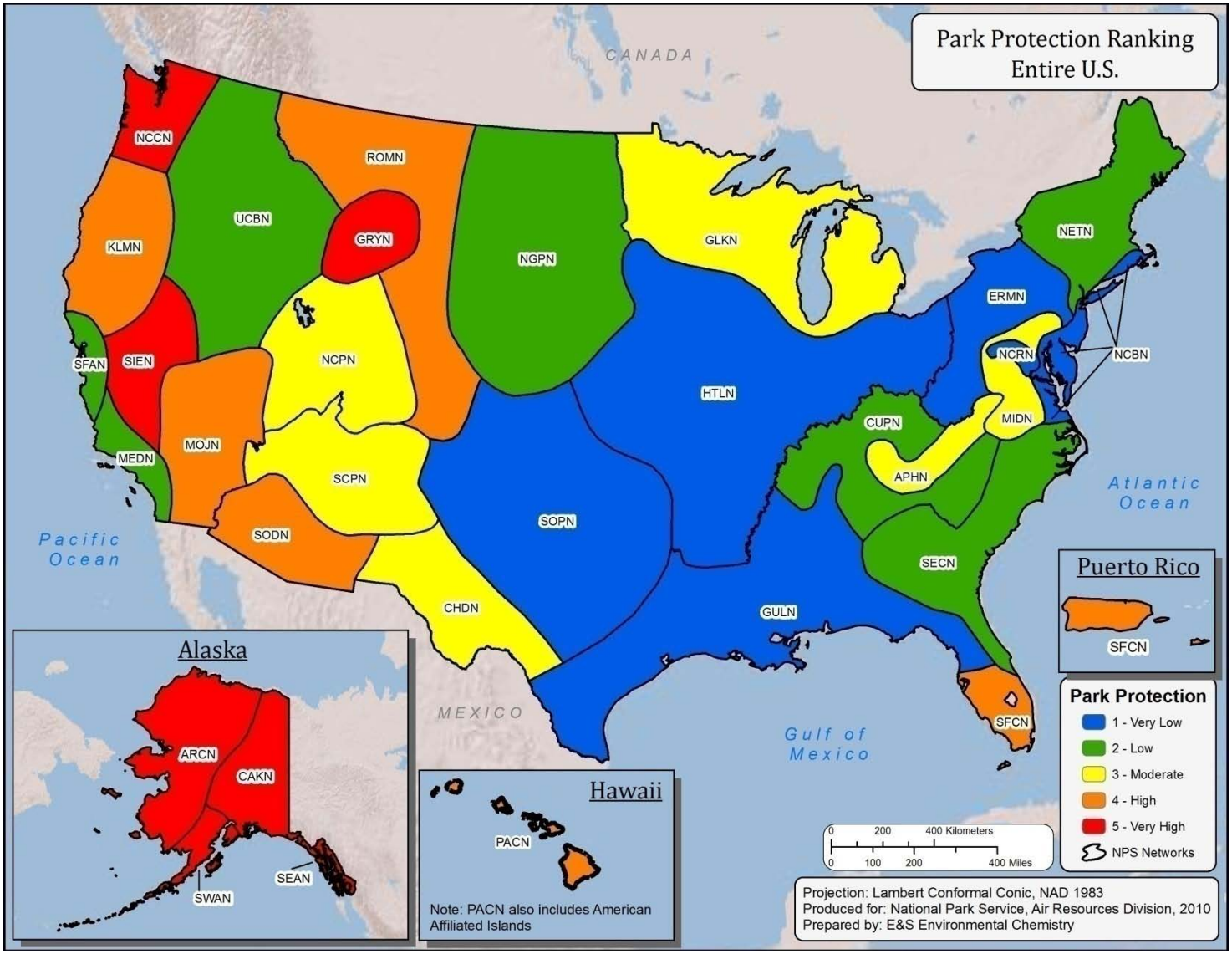
Figure 4. Results of the Summary Risk assessment to rank the 32 networks according to their likely risk of acidification effects, based on the average of the quintile ranks for S and N Pollutant Exposure, Ecosystem Sensitivity, and Park Protection metrics. Networks are color coded as described in the text.



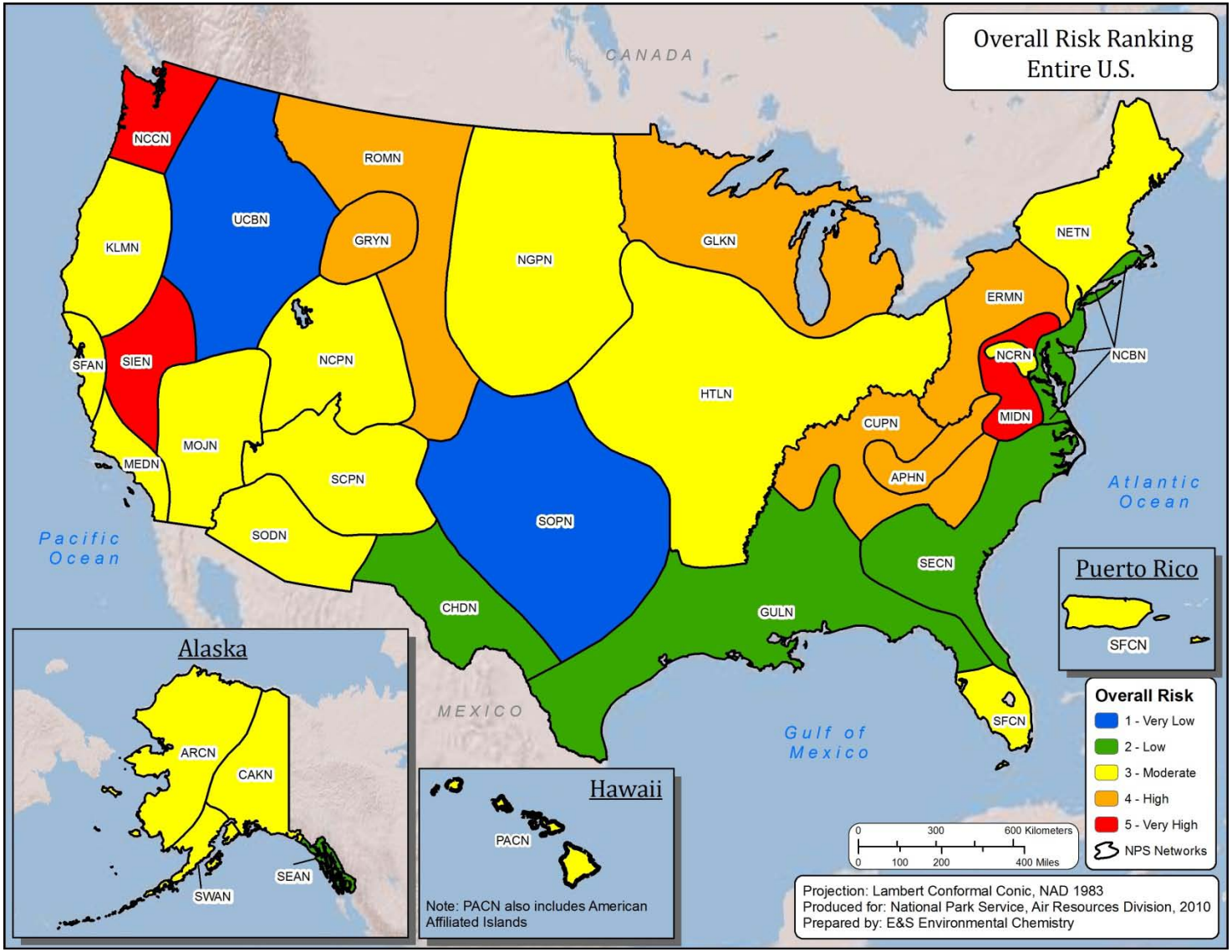
Map 7. Calculated Pollutant Exposure, by network, across the United States.



Map 8. Calculated Ecosystem Sensitivity, by network, across the United States.



Map 9. Calculated Park Protection, by network, across the United States.



Map 10. Calculated Summary Risk, by network, across the United States.

Table 5. Relative rankings of individual I&M parks, by network, for Pollutant Exposure, Ecosystem Sensitivity, Park Protection, and Summary Risk from acidification due to acidic deposition.

Network	I&M Parks[2] in Network	Relative Ranking of Individual Parks[1]			
		Pollutant Exposure	Ecosystem Sensitivity	Park Protection	Summary Risk
Appalachian Highlands	***Big South Fork***	High	Very High	Moderate	High
	Blue Ridge	High	Very High	High	Very High
	Great Smoky Mountains	High	Very High	Very High	Very High
	Obed	High	Very High	Moderate	High
Arctic	***Bering Land Bridge***	Very Low	Moderate	Moderate	Low
	Cape Krusenstern	Very Low	Low	Moderate	Low
	Gates of the Arctic	Very Low	Very High	Very High	High
	Kobuk Valley	Very Low	High	Very High	Moderate
	Noatak	Very Low	High	Very High	Moderate
Central Alaska	***Denali***	Very Low	Very High	Very High	High
	Wrangell-St. Elias	Very Low	Very High	Very High	High
	Yukon-Charley Rivers	Very Low	High	Moderate	Moderate
Chihuahuan Desert	Amistad	Low	Low	Moderate	Low
	Big Bend	Very Low	High	Very High	Moderate
	Carlsbad Caverns	Low	Very High	Very High	High
	Fort Davis	Very Low	Low	Moderate	Low
	Guadalupe Mountains	Low	High	Very High	High
	White Sands	Very Low	Low	Moderate	Low
Cumberland Piedmont	Abraham Lincoln Birthplace	Very High	Moderate	Moderate	High
	Carl Sandburg Home	High	Very High	Moderate	High
	Chickamauga and Chattanooga	Very High	Very High	Moderate	Very High
	Cowpens	High	Very Low	Moderate	Moderate
	Cumberland Gap	High	Very High	Moderate	High
	Fort Donelson	Very High	Moderate	Moderate	High
	Guilford Courthouse	Very High	Very Low	Moderate	Moderate
	Kings Mountain	High	Low	Moderate	Moderate
	Little River Canyon	Very High	Very High	Moderate	Very High
	Mammoth Cave	Very High	High	Very High	Very High
	Ninety Six	High	Very Low	Moderate	Moderate
	Russell Cave	Very High	High	Moderate	High
	Shiloh	High	Low	Moderate	Moderate
	Stones River	High	Very Low	Moderate	Moderate
Eastern Rivers and Mountains	Allegheny Portage Railroad	Very High	Very High	Moderate	Very High
	Bluestone	High	Very High	Moderate	High
	Delaware Water Gap	Very High	Very High	Moderate	Very High
	Fort Necessity	Very High	Very High	Moderate	Very High
	Friendship Hill	Very High	Moderate	Moderate	High
	Gauley River	Very High	Very High	Moderate	Very High
	Johnstown Flood	Very High	Very High	Moderate	Very High

Network	I&M Parks[2] in Network	Relative Ranking of Individual Parks[1]			
		Pollutant Exposure	Ecosystem Sensitivity	Park Protection	Summary Risk
Eastern Rivers and Mountains continued	***New River Gorge***	Very High	Very High	Moderate	Very High
	Upper Delaware	High	Very High	Moderate	High
Great Lakes	***Apostle Islands***	Moderate	Very High	Moderate	High
	Grand Portage	Low	High	Moderate	Moderate
	Indiana Dunes	Very High	Moderate	Moderate	High
	Isle Royale	Low	High	Very High	High
	Mississippi	High	Moderate	Moderate	Moderate
	Pictured Rocks	Moderate	Very High	Moderate	High
	Saint Croix	Moderate	Very High	Moderate	High
	Sleeping Bear Dunes	Moderate	High	Moderate	Moderate
	Voyageurs	Moderate	Very High	Very High	Very High
Greater Yellowstone	***Bighorn Canyon***	Very Low	High	Moderate	Moderate
	Grand Teton	Low	Very High	Very High	High
	Yellowstone	Low	Very High	Very High	High
Gulf Coast	***Big Thicket***	High	Low	Moderate	Moderate
	Gulf Islands	High	Very Low	High	Moderate
	Jean Lafitte	High	Very Low	Moderate	Moderate
	Natchez Trace Parkway and National Scenic Trail	High	High	Moderate	High
	Padre Island	Moderate	Very Low	Moderate	Low
	Palo Alto Battlefield	Moderate	Very Low	Moderate	Low
	San Antonio Missions	Moderate	Low	Moderate	Moderate
	Vicksburg	Moderate	Low	Moderate	Moderate
Heartland	Arkansas Post	Moderate	Very Low	Moderate	Low
	Buffalo	Moderate	Very High	High	High
	Cuyahoga Valley	Very High	High	Moderate	High
	Effigy Mounds	High	High	Moderate	High
	George Washington Carver	High	Very Low	Moderate	Moderate
	Herbert Hoover	High	Very Low	Moderate	Moderate
	Homestead	High	Low	Moderate	Moderate
	Hopewell Culture	Very High	Low	Moderate	Moderate
	Hot Springs	Moderate	Moderate	Moderate	Moderate
	Lincoln Boyhood	Very High	Low	Moderate	Moderate
	Ozark	High	Moderate	Moderate	Moderate
	Pea Ridge	High	Moderate	Moderate	Moderate
	Pipestone	Moderate	Low	Moderate	Moderate
	Tallgrass Prairie	High	High	Moderate	High
	Wilson's Creek	Moderate	Low	Moderate	Moderate
Klamath	***Crater Lake***	Low	Very High	Very High	High
	Lassen Volcanic	Low	Very High	Very High	High
	Lava Beds	Very Low	Very Low	Very High	Low
	Oregon Caves	Low	Low	Moderate	Low
	Redwood	Low	High	Very High	High
	Whiskeytown	Low	High	Moderate	Moderate
Mediterranean Coast	Cabrillo	Moderate	Low	Moderate	Moderate

Network	I&M Parks[2] in Network	Relative Ranking of Individual Parks[1]			
		Pollutant Exposure	Ecosystem Sensitivity	Park Protection	Summary Risk
Mediterranean Coast continued	***Channel Islands***	Moderate	High	Moderate	Moderate
	Santa Monica Mountains	High	High	Moderate	High
Mid-Atlantic	Appomattox Court House	High	Low	Moderate	Moderate
	Booker T. Washington	High	Very Low	Moderate	Moderate
	Eisenhower	Very High	Low	Moderate	Moderate
	Fredericksburg and Spotsylvania	Very High	Low	Moderate	Moderate
	Gettysburg	Very High	Moderate	Moderate	High
	Hopewell Furnace	Very High	Moderate	Moderate	High
	Petersburg	Very High	Low	Moderate	Moderate
	Richmond	Very High	Low	Moderate	Moderate
	Shenandoah	Very High	Very High	Very High	Very High
	Valley Forge	Very High	Moderate	Moderate	High
Mojave Desert	***Death Valley***	Very Low	Very High	Very High	High
	Great Basin	Very Low	Very High	Moderate	Moderate
	Joshua Tree	Moderate	High	Very High	High
	Lake Mead	Low	High	Very High	High
	Manzanar	Very Low	Very Low	Moderate	Very Low
	Mojave	Low	High	Very High	High
National Capital Region	Antietam	Very High	Very High	Moderate	Very High
	Catoctin Mountain	Very High	Very High	Moderate	Very High
	Chesapeake and Ohio Canal	Very High	Very High	Moderate	Very High
	George Washington	Very High	Moderate	Moderate	High
	Harpers Ferry	Very High	Very High	Moderate	Very High
	Manassas	Very High	Moderate	Moderate	High
	Monocacy	Very High	Moderate	Moderate	High
	National Capital Parks - East	Very High	High	Moderate	High
	Prince William Forest	Very High	Moderate	Moderate	High
	Rock Creek Park	Very High	Moderate	Moderate	High
	Wolf Trap National Park for the Performing Arts	Very High	Moderate	Moderate	High
North Coast and Cascades	Ebey's Landing	Moderate	Very Low	Moderate	Low
	Fort Vancouver	Moderate	Very Low	Moderate	Low
	Lewis and Clark	Moderate	Low	Moderate	Moderate
	Mount Rainier	Moderate	Very High	Very High	Very High
	North Cascades	Moderate	Very High	Very High	Very High
	Olympic	Moderate	Very High	Very High	Very High
	San Juan Island	Moderate	Very Low	Moderate	Low
Northeast Coastal and Barrier	Assateague Island	Very High	Very Low	Moderate	Moderate
	Cape Cod	High	High	Moderate	High
	Colonial	Very High	Low	Moderate	Moderate
	Fire Island	Very High	Very Low	High	Moderate
	Gateway	Very High	Low	Moderate	Moderate
	George Washington Birthplace	Very High	Very Low	Moderate	Moderate

Network	I&M Parks[2] in Network	Relative Ranking of Individual Parks[1]			
		Pollutant Exposure	Ecosystem Sensitivity	Park Protection	Summary Risk
Northeast Coastal and Barrier continued	Sagamore Hill	Very High	Low	Moderate	Moderate
	Thomas Stone	Very High	Low	Moderate	Moderate
Northeast Temperate	Acadia	Moderate	Very High	Very High	Very High
	Boston Harbor Islands	Very High	Low	Moderate	Moderate
	Home of Franklin D. Roosevelt	Very High	Moderate	Moderate	High
	Marsh-Billings-Rockefeller	Moderate	Very High	Moderate	High
	Minute Man	High	High	Moderate	High
	Morristown	Very High	Very High	Moderate	Very High
	Saint-Gaudens	Moderate	Very High	Moderate	High
	Saratoga	Moderate	Moderate	Moderate	Moderate
	Saugus Iron Works	Very High	High	Moderate	High
	Vanderbilt Mansion	Very High	Moderate	Moderate	High
	Weir Farm	Very High	High	Moderate	High
Northern Colorado Plateau	***Arches***	Very Low	Moderate	Very High	Moderate
	Black Canyon of the Gunnison	Very Low	High	High	Moderate
	Bryce Canyon	Very Low	High	Very High	Moderate
	Canyonlands	Very Low	High	Very High	Moderate
	Capitol Reef	Very Low	High	Very High	Moderate
	Cedar Breaks	Very Low	High	High	Moderate
	Colorado	Low	High	Moderate	Moderate
	Curecanti	Very Low	Very High	Moderate	Moderate
	Dinosaur	Low	High	Moderate	Moderate
	Fossil Butte	Low	Moderate	Moderate	Moderate
	Golden Spike	Low	Low	Moderate	Low
	Hovenweep	Moderate	Low	Moderate	Moderate
	Natural Bridges	Low	Moderate	Moderate	Moderate
	Pipe Spring	Very Low	Very Low	Moderate	Very Low
	Timpanogos Cave	Moderate	Moderate	High	Moderate
	Zion	Very Low	High	Very High	Moderate
Northern Great Plains	Agate Fossil Beds	Low	Moderate	Moderate	Moderate
	Badlands	Very Low	Moderate	Very High	Moderate
	Devils Tower	Low	Moderate	Moderate	Moderate
	Fort Laramie	Moderate	Low	Moderate	Moderate
	Fort Union Trading Post	Low	Very Low	Moderate	Low
	Jewel Cave	Low	High	Moderate	Moderate
	Knife River Indian Villages	Moderate	Very Low	Moderate	Low
	Missouri	Moderate	Moderate	Moderate	Moderate
	Mount Rushmore	Low	Low	High	Moderate
	Niobrara	Low	Moderate	High	Moderate
	Scotts Bluff	Moderate	Low	Moderate	Moderate
	Theodore Roosevelt	Moderate	Moderate	Very High	High
	Wind Cave	Low	Very High	Very High	High
Pacific Island	American Memorial Park	ND	Moderate	Moderate	Moderate
	Haleakala	Moderate	Very High	Very High	Very High

Network	I&M Parks[2] in Network	Relative Ranking of Individual Parks[1]			
		Pollutant Exposure	Ecosystem Sensitivity	Park Protection	Summary Risk
Pacific Island continued	***Hawaii Volcanoes***	Low	High	Very High	High
	Kalaupapa	Very High	Moderate	Moderate	High
	Kaloko-Honokohau	Low	Very Low	Moderate	Low
	National Park of American Samoa	ND	Moderate	Moderate	Moderate
	Pu'uhonua o Honaunau	Low	Low	Moderate	Low
	Puukohola Heiau	Low	Low	Moderate	Low
	War in the Pacific	ND	Moderate	Moderate	Moderate
Rocky Mountain	Florissant Fossil Beds	Moderate	High	Moderate	Moderate
	Glacier	Low	Very High	Very High	High
	Grant-Kohrs Ranch	Very Low	Very Low	Moderate	Very Low
	Great Sand Dunes	Very Low	Very High	Very High	High
	Little Bighorn Battlefield	Low	Very Low	Moderate	Low
	Rocky Mountain	Moderate	Very High	Very High	Very High
San Francisco Bay Area	Fort Point	Moderate	Low	Moderate	Moderate
	Golden Gate	Moderate	High	High	High
	John Muir	High	Low	Moderate	Moderate
	Muir Woods	High	Moderate	Moderate	Moderate
	Pinnacles	Moderate	High	High	High
	Point Reyes	High	Moderate	High	High
Sierra Nevada	Devils Postpile	Low	High	Very High	High
	Kings Canyon	Low	Very High	Very High	High
	Sequoia	Low	Very High	Very High	High
	Yosemite	Moderate	Very High	Very High	Very High
Sonoran Desert	Casa Grande Ruins	Moderate	Very Low	Moderate	Low
	Chiricahua	Very Low	High	Very High	Moderate
	Coronado	Very Low	Low	High	Low
	Fort Bowie	Very Low	Low	Moderate	Low
	Gila Cliff Dwellings	Very Low	Moderate	High	Moderate
	Montezuma Castle	Low	Low	Moderate	Low
	Organ Pipe Cactus	Very Low	Moderate	Very High	Moderate
	Saguaro	Low	High	Very High	High
	Tonto	Moderate	Moderate	Moderate	Moderate
	Tumacacori	Low	Very Low	Moderate	Low
	Tuzigoot	Low	Low	Moderate	Low
South Florida/Caribbean	***Big Cypress***	High	Very Low	High	Moderate
	Biscayne	High	Very Low	Moderate	Moderate
	Buck Island Reef	High	Very Low	Moderate	Moderate
	Dry Tortugas	High	Very Low	Moderate	Moderate
	Everglades	High	Low	Very High	High
	Virgin Islands	High	Moderate	Very High	High
Southeast Alaska	***Glacier Bay***	Very Low	High	Very High	Moderate
	Klondike Gold Rush	Very Low	High	Moderate	Moderate
	Sitka	Very Low	Low	Moderate	Low
Southeast Coast	Canaveral	High	Very Low	Moderate	Moderate
	Cape Hatteras	High	Very Low	Moderate	Moderate

Network	I&M Parks[2] in Network	Relative Ranking of Individual Parks[1]			
		Pollutant Exposure	Ecosystem Sensitivity	Park Protection	Summary Risk
Southeast Coast continued	Cape Lookout	High	Very Low	Moderate	Moderate
	Castillo de San Marcos	High	Very Low	Moderate	Moderate
	Chattahoochee River	Very High	High	Moderate	High
	Congaree	High	Low	High	Moderate
	Cumberland Island	High	Low	High	Moderate
	Fort Caroline	High	Very Low	Moderate	Moderate
	Fort Frederica	High	Very Low	Moderate	Moderate
	Fort Matanzas	High	Very Low	Moderate	Moderate
	Fort Pulaski	High	Very Low	Moderate	Moderate
	Fort Sumter	High	Very Low	Moderate	Moderate
	Horseshoe Bend	High	Moderate	Moderate	Moderate
	Kennesaw Mountain	Very High	Moderate	Moderate	High
	Moores Creek	Very High	Very Low	Moderate	Moderate
	Ocmulgee	High	Very Low	Moderate	Moderate
	Timucaun Ecological and Historical Preserve	High	Low	Moderate	Moderate
Southern Colorado Plateau	Aztec Ruins	Moderate	Very Low	Moderate	Low
	Bandelier	Low	High	Very High	High
	Canyon de Chelly	Low	High	Moderate	Moderate
	Chaco Culture	Low	Moderate	Moderate	Moderate
	El Malpais	Low	Low	High	Moderate
	El Morro	Moderate	Very Low	Moderate	Low
	Glen Canyon	Very Low	High	High	Moderate
	Grand Canyon	Low	Very High	Very High	High
	Hubbell Trading Post	Low	Very Low	Moderate	Low
	Mesa Verde	Moderate	High	Very High	High
	Navajo	Very Low	Moderate	Moderate	Low
	Petrified Forest	Low	Moderate	Very High	Moderate
	Petroglyph	Low	Low	Moderate	Low
	Rainbow Bridge	Very Low	Moderate	Moderate	Low
	Salinas Pueblo Missions	Very Low	Low	Moderate	Low
	Sunset Crater Volcano	Low	Low	Moderate	Low
	Walnut Canyon	Low	Moderate	Moderate	Moderate
	Wupatki	Very Low	Moderate	Moderate	Low
	Yucca House	Moderate	Very Low	Moderate	Low
Southern Plains	Alibates Flint Quarries	Moderate	Low	Moderate	Moderate
	Bent's Old Fort	Low	Very Low	Moderate	Low
	Capulin Volcano	Very Low	Low	Moderate	Low
	Chickasaw	Moderate	Low	Moderate	Moderate
	Fort Larned	Moderate	Very Low	Moderate	Low
	Fort Union	Very Low	Very Low	Moderate	Very Low
	Lake Meredith	Moderate	Moderate	Moderate	Moderate
	Lyndon B. Johnson	Moderate	Very Low	Moderate	Low
	Pecos	Low	High	Moderate	Moderate
	Washita Battlefield	Moderate	Very Low	Moderate	Low
Southwest Alaska	Alagnak	Very Low	Low	High	Low

Network	I&M Parks[2] in Network	Relative Ranking of Individual Parks[1]			
		Pollutant Exposure	Ecosystem Sensitivity	Park Protection	Summary Risk
Southwest Alaska continued	***Aniakchak***	Very Low	High	Moderate	Moderate
	Katmai	Very Low	Very High	Very High	High
	Kenai Fjords	Very Low	High	High	Moderate
	Lake Clark	Very Low	Very High	Very High	High
Upper Columbia Basin	Big Hole	Very Low	Moderate	Moderate	Low
	City of Rocks	Very Low	High	Moderate	Moderate
	Craters of the Moon	Very Low	Very Low	High	Low
	Hagerman Fossil Beds	Low	Moderate	Moderate	Moderate
	John Day Fossil Beds	Very Low	Moderate	Moderate	Low
	Lake Roosevelt	Very Low	Moderate	Moderate	Low
	Nez Perce	Very Low	Moderate	Moderate	Low
	Whitman Mission	Low	Very Low	Moderate	Low

[1] Relative park rankings are designated according to quintile ranking, among all I&M Parks, from the lowest quintile (Very Low risk) to the highest quintile (Very High risk).
[2] Park names are printed in bold italic for parks larger than 100 square miles.

3.1.2 Parks

All of the I&M parks, regardless of size, were ranked according to each of the three themes used to represent the components of risk and for the Summary Risk metric. Results of park-specific rankings for all I&M parks are summarized in Table 5 and in Appendix B. These results cannot be represented graphically in an effective manner because there are too many (272) I&M parks. Most of these parks are very small, and therefore contain only limited pollution-sensitive resources. There are 79 parks larger than 100 square miles in area. These are the parks large enough that most are readily visible at the scale of the network maps. We therefore graph the park-specific results only for these larger parks. Results are given in Figures 5 through 7 for the park-specific Pollutant Exposure, Ecosystem Sensitivity, and Park Protection, respectively. In each case, the ranks shown for the large parks reflect rankings relative to all parks regardless of size. Bars on the graphs are color coded to reflect ranking quintiles. Parks in the highest quintile (highest 20% of risk rankings) are coded red. Parks in the second highest quintile are coded orange. This pattern is continued, from warm colors to cool colors, with the lowest quintile coded as blue, reflecting the 20% of parks having lowest risk. Note that only 3 of the 79 largest parks occurred in the highest quintile for Pollutant Exposure (Figure 5). This was because the smaller parks are disproportionately located in the eastern United States and were more heavily skewed towards high Pollutant Exposure. In contrast, the large parks were more heavily skewed (compared to all parks regardless of size) towards high Ecosystem Sensitivity and Park Protection (Figures 6 and 7). Figure 8 depicts results of the Summary Risk assessment ranking according to each park's likely risk of acidification effects, based on an average of the quintile ranks for the three themes: Pollutant Exposure, Ecosystem Sensitivity, and Park Protection.

These rankings for the 79 largest I&M parks are shown in Maps 11–14. Each park is represented by a star, color coded to reflect its ranking. The ranks for each theme ranged from Very Low (blue) to Very High (red). Individual park-specific results for all parks, regardless of size, are presented in tabular form and discussed in the individual network sections of this report. Some networks do not have any parks larger than 100 square miles. For such networks, Figures E through H are omitted.

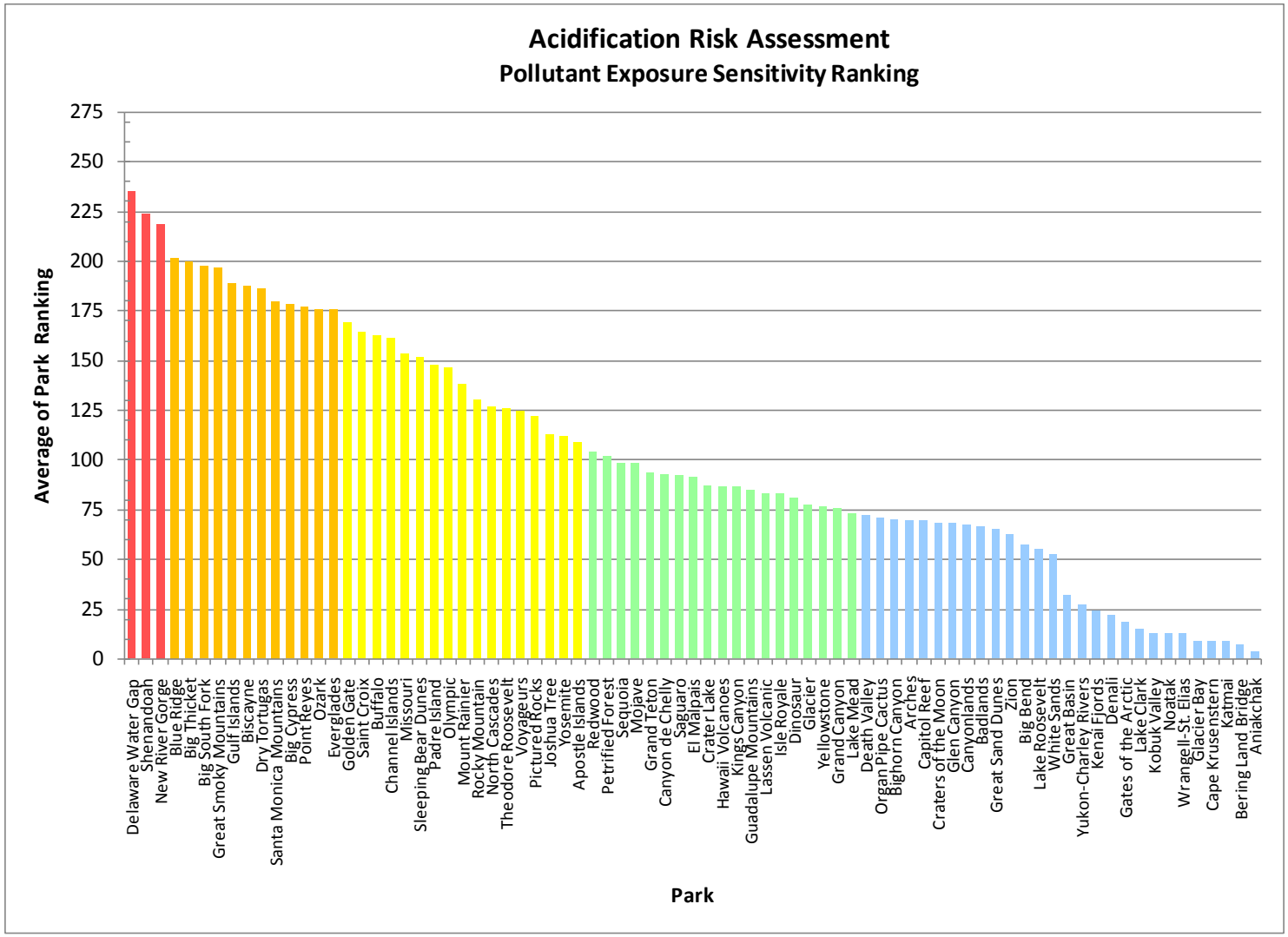


Figure 5. Calculated S and N Pollutant Exposure ranking, expressed relative to all I&M parks, for each of the 79 I&M parks larger than 100 square miles. Parks are color coded by quintile, from the highest 20% of rankings among all 272 I&M parks (red) to the lowest 20% of rankings (blue).

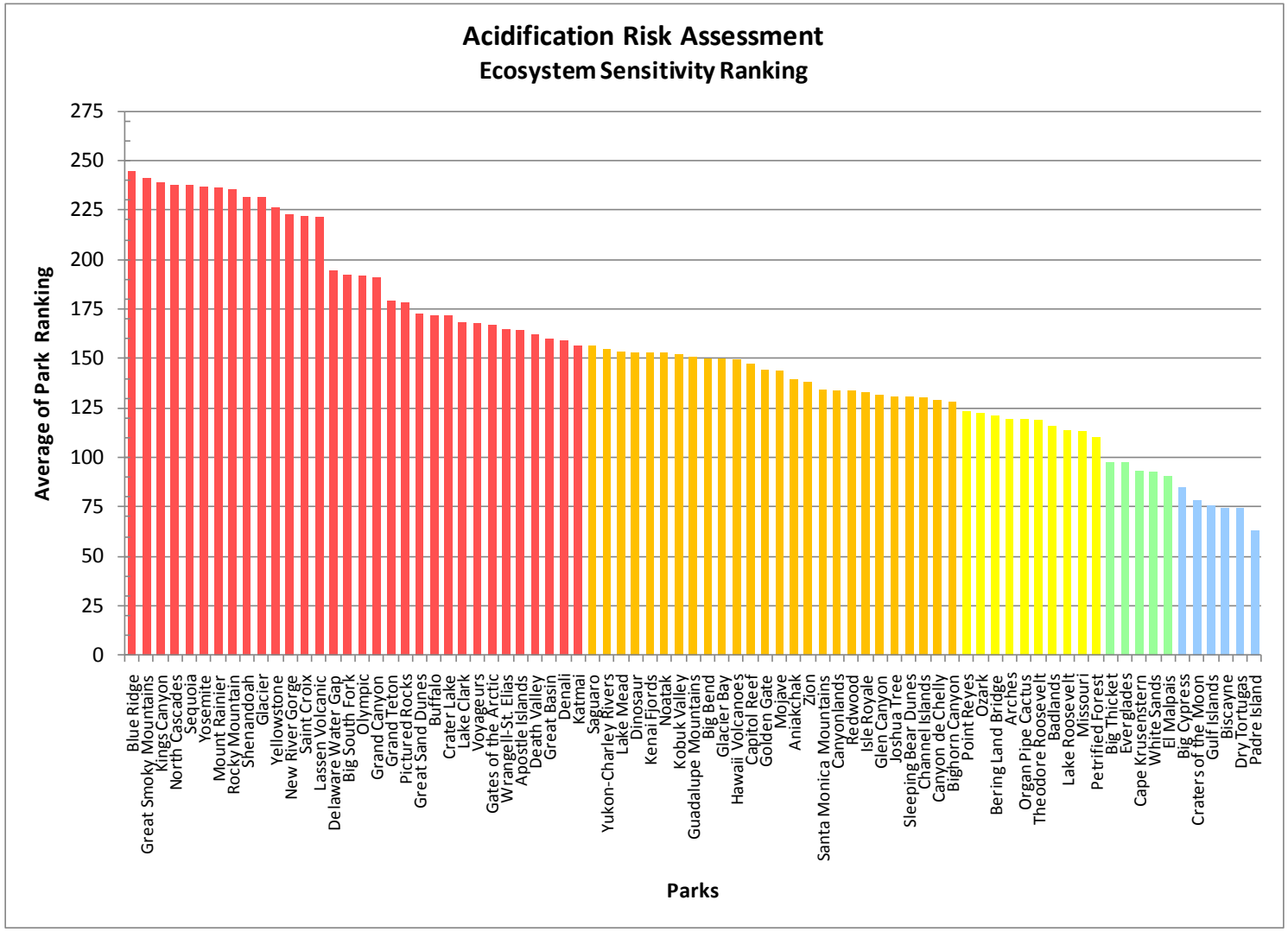


Figure 6. Calculated Ecosystem Sensitivity ranking, expressed relative to all I&M parks, for each of the 79 I&M parks larger than 100 square miles. Parks are color coded by quintile, from the highest 20% of rankings among all 272 I&M parks (red) to the lowest 20% of rankings (blue).

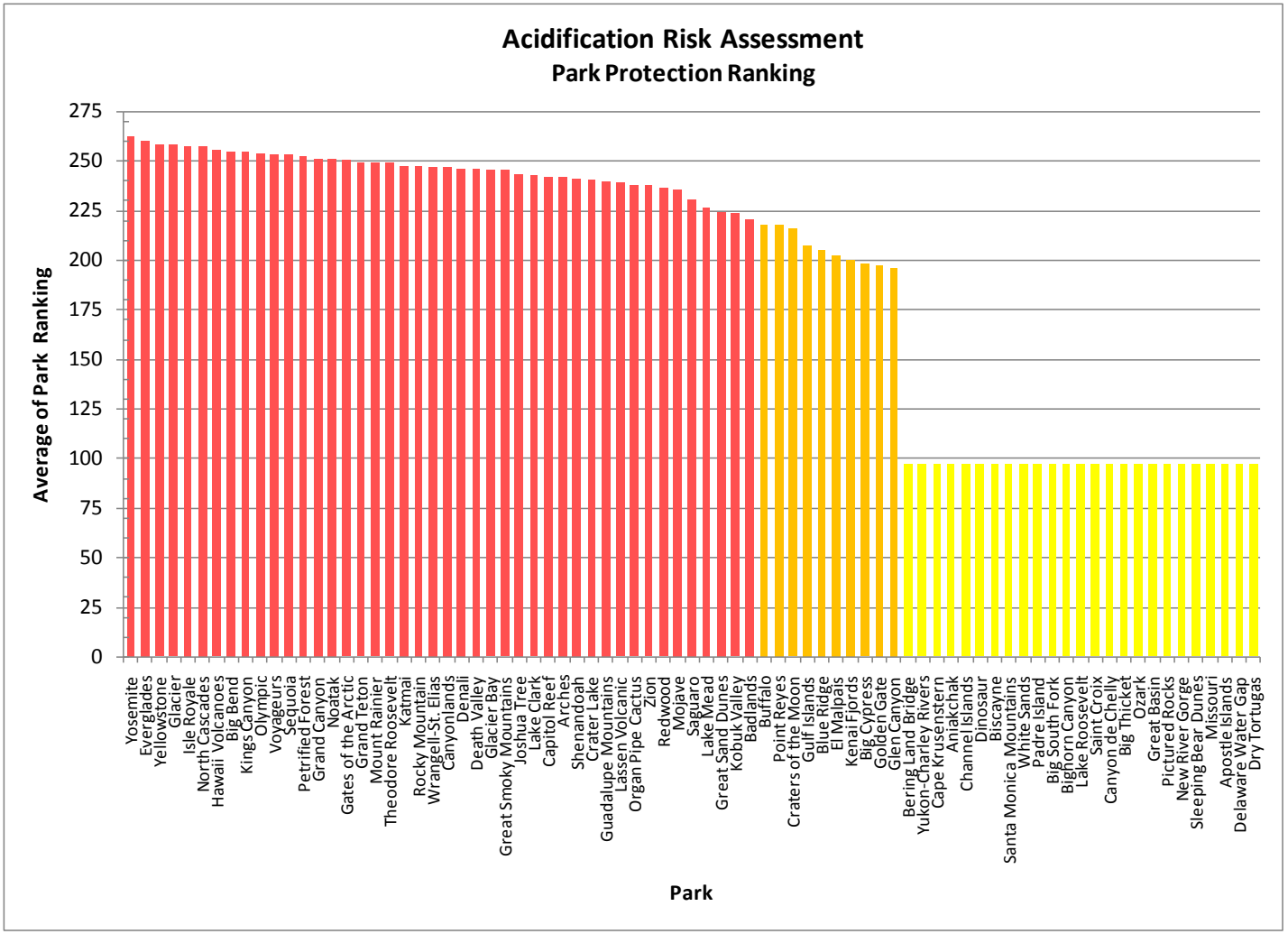


Figure 7. Calculated Park Protection ranking, expressed relative to all I&M parks, for each of the 79 I&M parks larger than 100 square miles. Parks are color coded by quintile, from the highest 20% of rankings among all 272 I&M parks (red) to the lowest 20% of rankings. The majority of parks had no land designated as wilderness or Class I. Averaging of Park Protection across all parks placed all of these parks that lacked any special protection into the middle quintile. Thus, there are no parks that receive a Park Protection ranking in the lowest (blue) or second lowest (green) quintile.

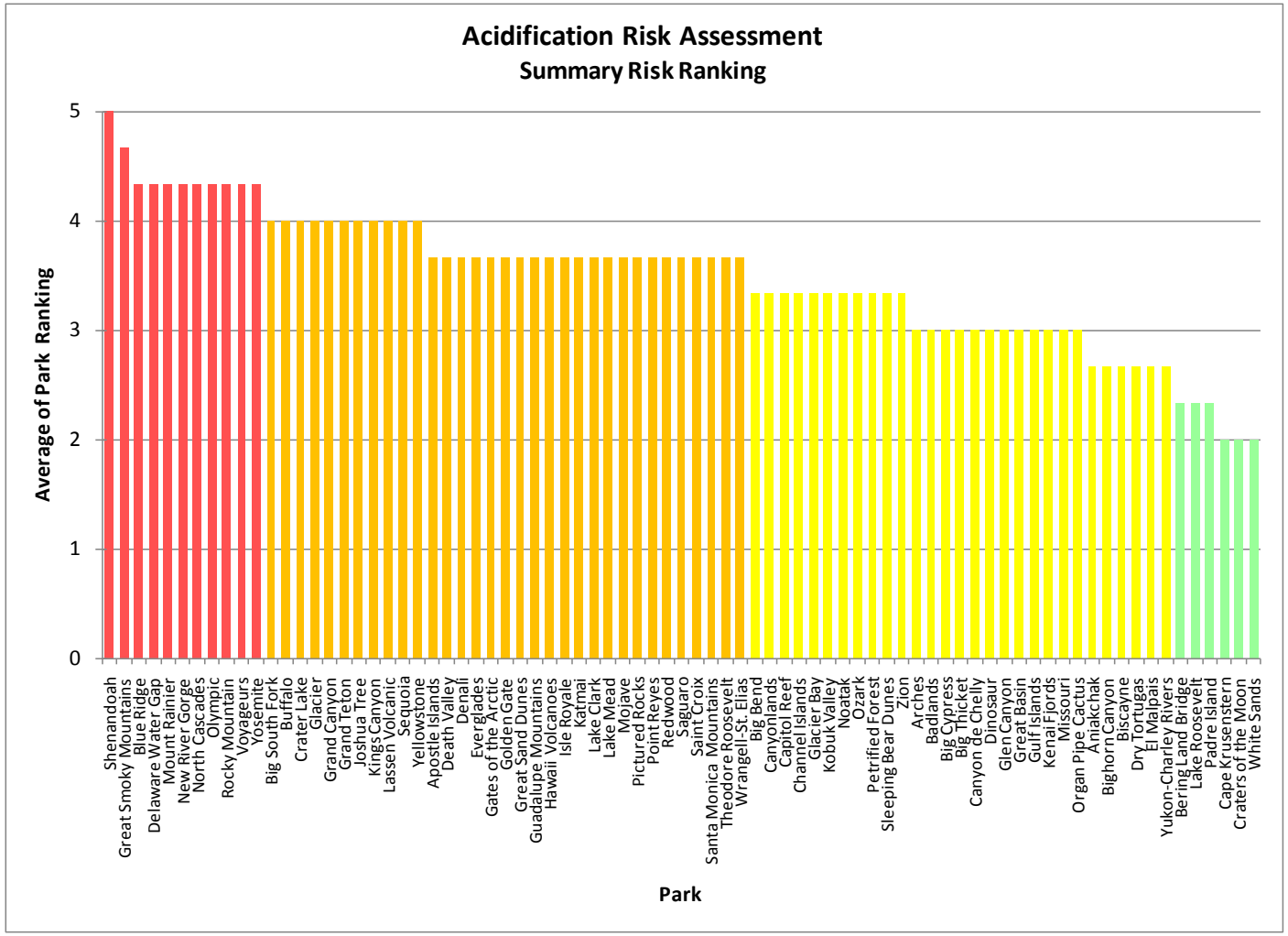
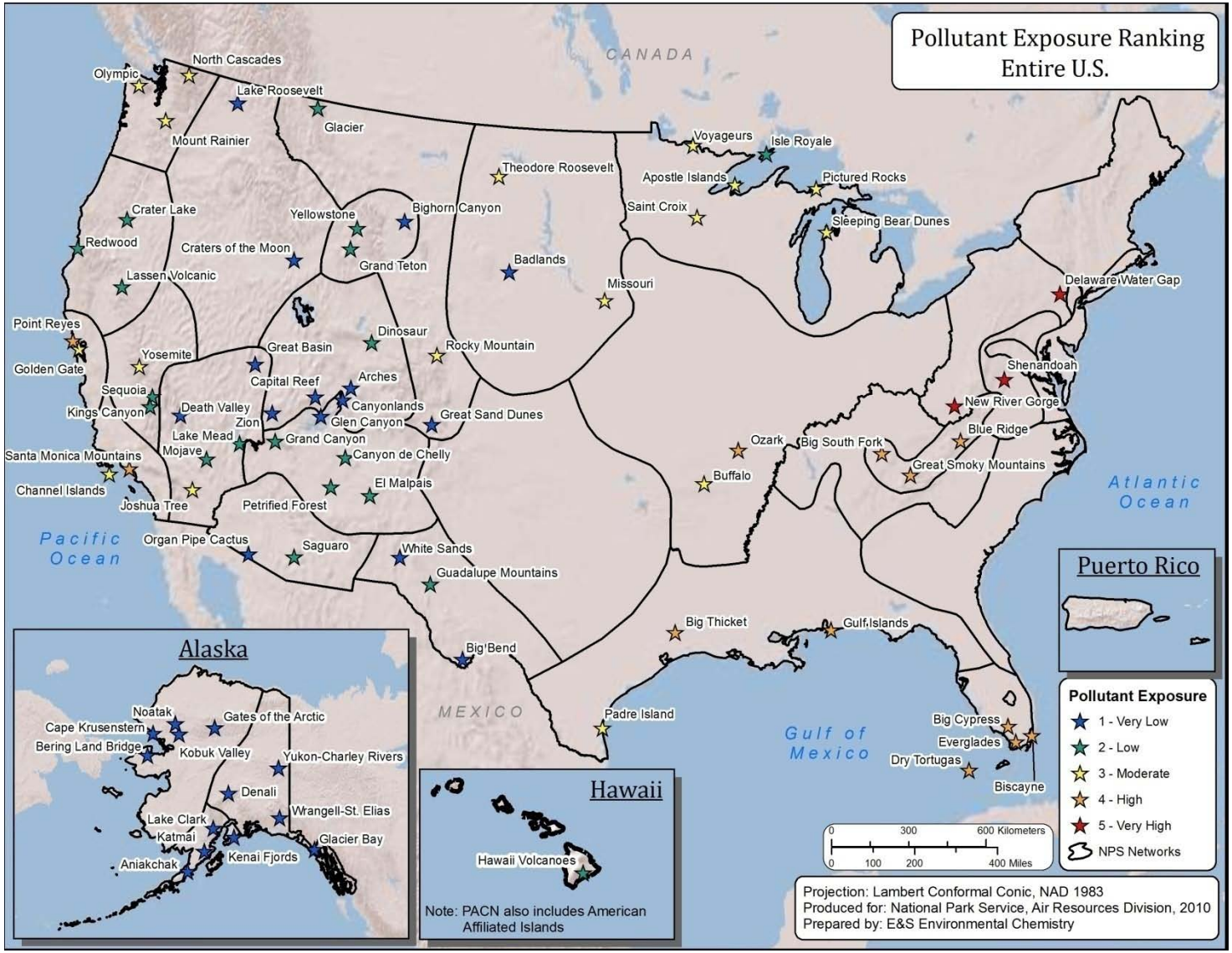
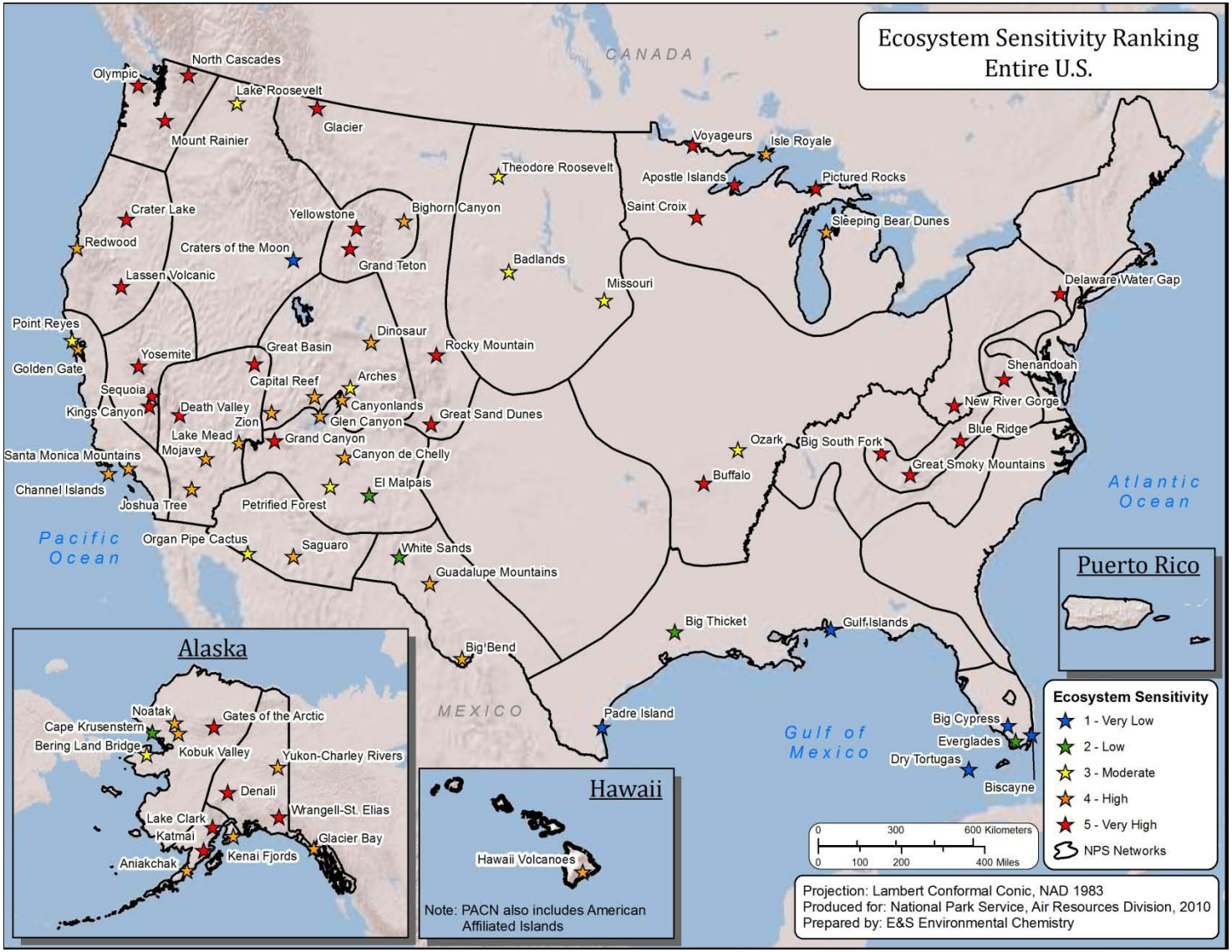


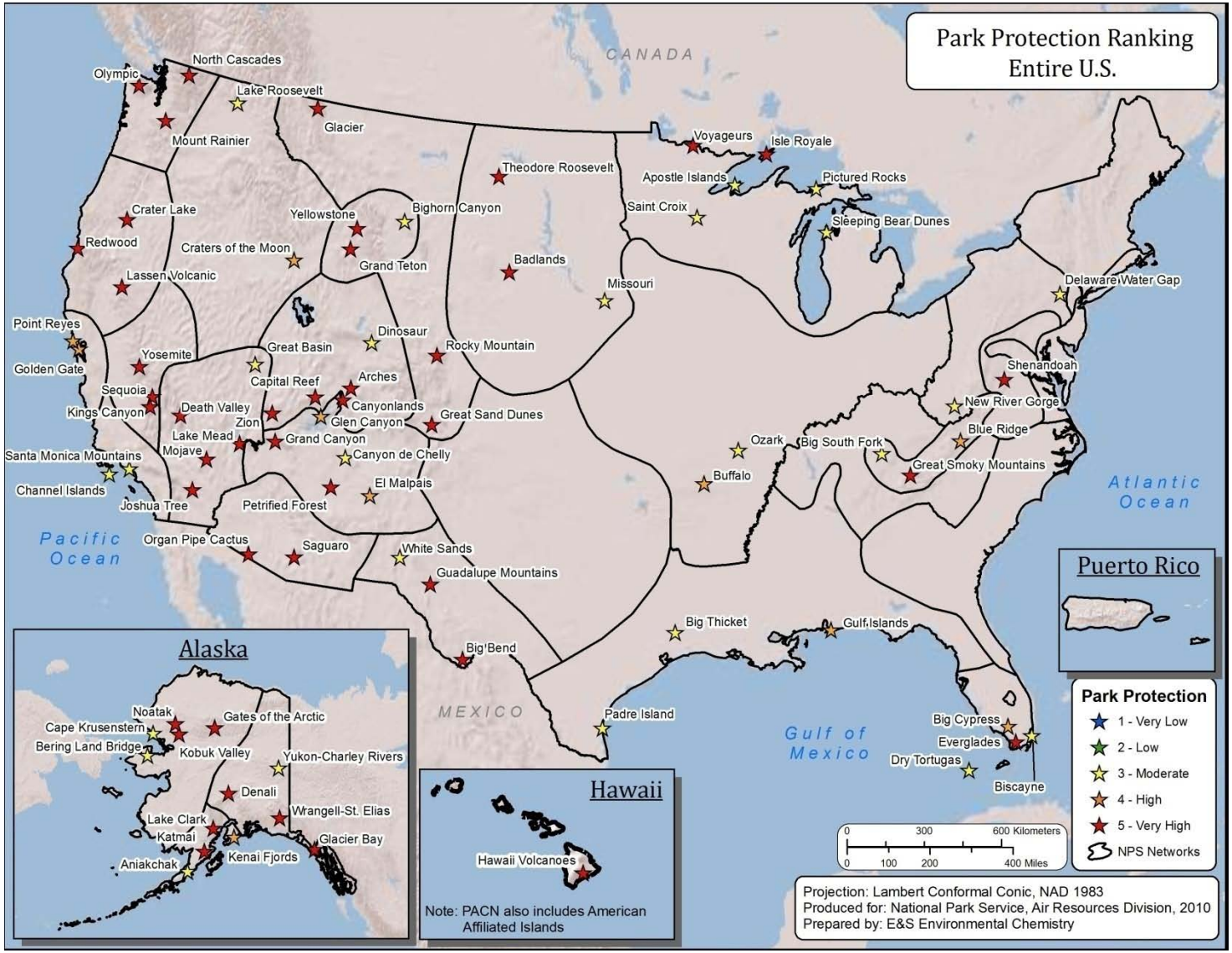
Figure 8. Results of the Summary Risk assessment ranking the 79 I&M parks that are larger than 100 square miles according to their likely risk of acidification effects, based on an average of the quintile ranks for the three themes: Pollutant Exposure, Ecosystem Sensitivity, and Park Protection. Parks are color coded by class, from the highest rankings among all 272 I&M parks (red) to the lowest rankings (blue). Note that these larger parks are skewed towards the higher risk rankings (highest quintiles; red and orange) compared with the smaller parks that do not appear on the graph. None of the larger parks were classified as having Very Low Summary Risk.



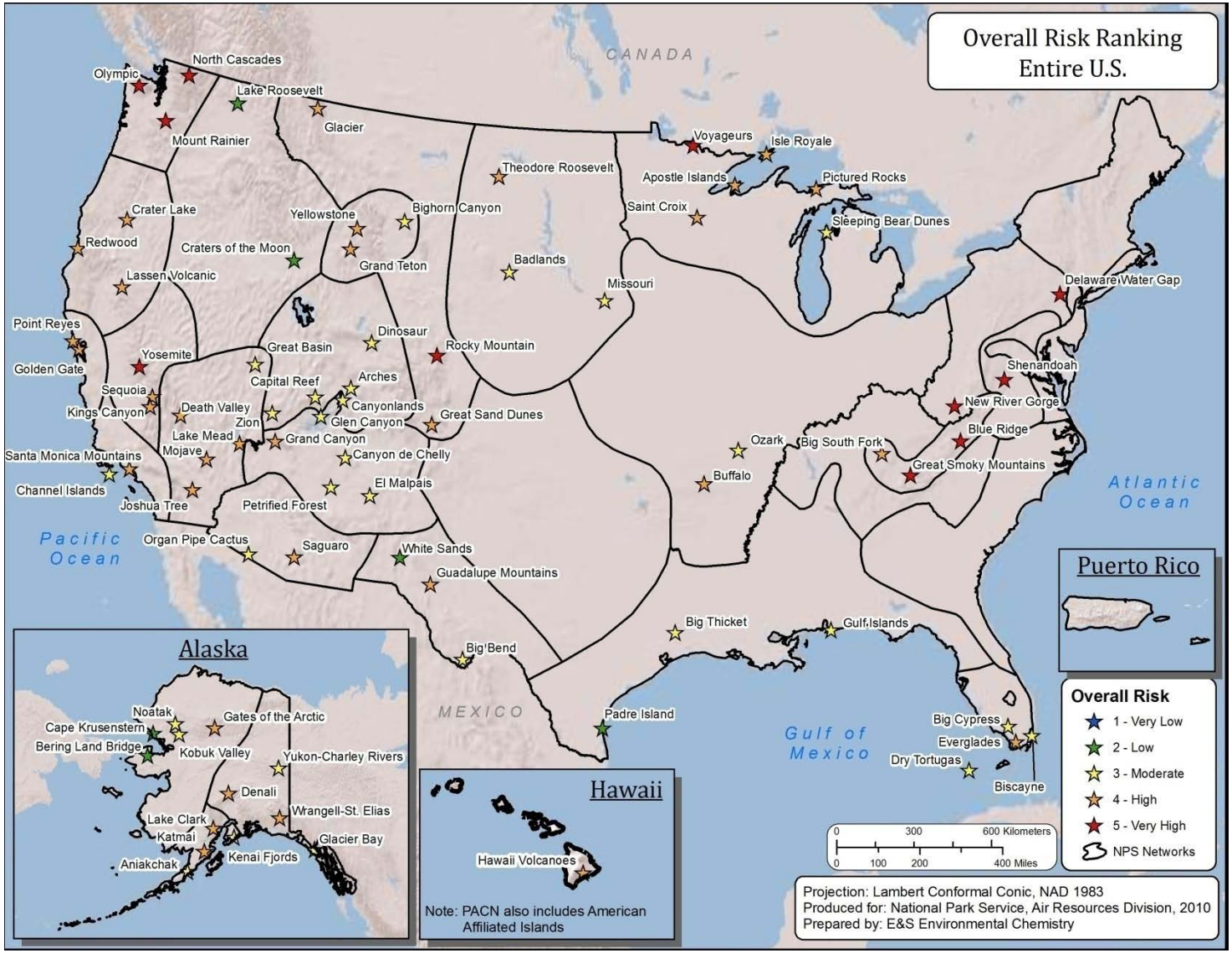
Map 11. Calculated Pollutant Exposure, by park, across the United States for all I&M parks larger than 100 square miles.



Map 12. Calculated Ecosystem Sensitivity, by park, across the United States for all I&M parks larger than 100 square miles.



Map 13. Calculated Park Protection, by park, across the United States for all I&M parks larger than 100 square miles.



Map 14. Calculated Summary Risk, by park, across the United States for all I&M parks larger than 100 square miles.

3.2 Results by Network

Results for the individual I&M networks are discussed in more detail in an associated series of 32 reports. Each report provides network-specific information and maps for the three factors used in the risk analysis, including pollutant exposure, ecosystem sensitivity, and level of park protection. Each network report has charts showing that network's relative ranking for each of the three factors, and the network's relative ranking in terms of overall risk of acidification from atmospheric deposition of S and N compounds. Network reports are available from the:

Air Resources Division of the NPS

http://www.nature.nps.gov/air/Permits/ARIS/networks/acidification-eval.cfm

NPS NRInfo portal

https://nrinfo.nps.gov/Reference.mvc/Profile?

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Appendices

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Appendix A: Rankings of all Park-Specific Variables for Each of the 271 I&M Parks

Table A-1. Pollutant Exposure Variables

Park Name	Network Name	Park Area (square miles)	Average N Deposition	Ranking for Average N Deposition	Average S Deposition	Ranking for Average S Deposition	N Emissions by County	Ranking for N Emissions by County	S Emissions by County
Abraham Lincoln Birthplace	Cumberland Piedmont	0.53	12.80	231.0	14.70	237.0	7.21	212.0	12.67
Acadia	Northeast Temperate	60.61	4.60	137.0	5.20	160.0	1.69	110.0	0.83
Agate Fossil Beds	Northern Great Plains	4.76	3.30	114.0	0.90	107.5	1.52	96.0	0.54
Alagnak	Southwest Alaska	48.29	No Data		No Data		0.03	6.0	0.00
Alibates Flint Quarries	Southern Plains	2.14	7.00	159.5	7.40	183.0	3.47	140.0	1.33
Allegheny Portage Railroad	Eastern Rivers and Mountains	1.67	14.40	252.0	30.80	268.0	8.40	227.0	20.70
American Memorial Park	Pacific Island	0.21	No Data		No Data		No Data		No Data
Amistad	Chihuahuan Desert	89.95	5.40	148.5	2.40	139.0	0.81	49.0	0.08
Aniakchak	Southwest Alaska	942.86	No Data		No Data		0.01	4.0	0.00
Antietam	National Capital Region	5.08	13.60	241.0	15.30	241.5	10.04	246.0	10.93
Apostle Islands	Great Lakes	107.42	4.70	140.0	3.20	144.5	1.04	69.0	0.44
Appomattox Court House	Mid Atlantic	2.78	11.10	209.5	11.00	207.0	4.96	173.0	5.92
Arches	Northern Colorado Plateau	119.47	2.00	52.5	0.50	63.0	0.97	63.0	0.60
Arkansas Post	Heartland	0.66	11.40	215.0	6.90	179.0	3.27	136.0	1.15
Assateague Island	Northeast Coastal and Barrier	76.15	8.30	171.0	12.40	219.0	10.29	249.0	13.81
Aztec Ruins	Southern Colorado Plateau	0.49	3.60	124.0	1.30	127.0	1.62	101.0	1.19

Park Name	Network Name	Park Area (square miles)	Average N Deposition	Ranking for Average N Deposition	Average S Deposition	Ranking for Average S Deposition	N Emissions by County	Ranking for N Emissions by County	S Emissions by County
Badlands	Northern Great Plains	379.27	3.20	110.0	0.80	96.5	0.65	31.0	0.11
Bandelier	Southern Colorado Plateau	52.80	2.80	98.0	0.80	96.5	1.13	76.0	0.34
Bent's Old Fort	Southern Plains	1.25	2.90	101.5	0.50	63.0	1.24	81.0	0.59
Bering Land Bridge	Arctic	4351.17	No Data		No Data		0.03	7.0	0.01
Big Bend	Chihuahuan Desert	1270.68	2.30	69.5	0.90	107.5	0.48	23.0	0.11
Big Cypress	South Florida Caribbean	1139.86	7.00	159.5	5.80	166.0	6.60	201.0	3.56
Big Hole	Upper Columbia Basin	1.05	1.60	36.0	0.40	50.5	0.36	16.0	0.03
Big South Fork	Appalachian Highlands	191.41	11.00	208.0	13.30	226.0	4.24	160.0	4.95
Big Thicket	Gulf Coast	138.78	10.70	204.0	8.70	190.0	7.04	210.0	4.70
Bighorn Canyon	Greater Yellowstone	186.79	2.10	59.0	0.80	96.5	0.75	41.0	0.46
Biscayne	South Florida Caribbean	274.36	6.20	157.0	7.70	185.0	7.78	216.0	4.47
Black Canyon of the Gunnison	Northern Colorado Plateau	48.99	2.40	75.0	0.80	96.5	0.81	50.0	0.17
Blue Ridge	Appalachian Highlands	141.45	10.50	200.5	11.40	209.5	5.44	185.0	6.11
Bluestone	Eastern Rivers and Mountains	6.78	9.60	185.5	13.10	223.5	4.32	162.0	7.20
Booker T. Washington	Mid Atlantic	0.37	9.10	177.5	9.20	194.0	4.66	169.0	5.81
Boston Harbor Islands	Northeast Temperate	2.49	No Data		No Data		9.09	235.0	6.97
Bryce Canyon	Northern Colorado Plateau	56.23	2.10	59.0	0.40	50.5	0.70	36.0	0.16
Buck Island Reef	South Florida Caribbean	29.67	No Data		No Data		7.79	217.0	2.87
Buffalo	Heartland	146.16	9.60	185.5	5.90	168.0	3.76	148.0	1.36
Cabrillo	Mediterranean Coast	0.25	3.60	124.0	3.20	144.5	8.74	232.0	1.20
Canaveral	Southeast Coast	91.34	7.70	168.0	8.40	188.5	7.66	215.0	7.07

Park Name	Network Name	Park Area (square miles)	Average N Deposition	Ranking for Average N Deposition	Average S Deposition	Ranking for Average S Deposition	N Emissions by County	Ranking for N Emissions by County	S Emissions by County
Canyon de Chelly	Southern Colorado Plateau	144.62	1.70	39.5	0.50	63.0	1.86	114.0	1.50
Canyonlands	Northern Colorado Plateau	523.32	1.90	47.5	0.40	50.5	0.98	65.0	0.65
Cape Cod	Northeast Coastal and Barrier	63.35	5.90	154.5	10.20	200.5	12.17	264.0	9.52
Cape Hatteras	Southeast Coast	48.58	7.10	162.0	9.80	198.0	6.20	199.0	3.38
Cape Krusenstern	Arctic	1031.23	No Data		No Data		0.06	11.0	0.00
Cape Lookout	Southeast Coast	43.66	7.10	162.0	10.20	200.5	7.62	214.0	2.80
Capitol Reef	Northern Colorado Plateau	381.42	2.10	59.0	0.50	63.0	0.98	66.0	0.55
Capulin Volcano	Southern Plains	1.24	2.50	83.0	0.60	74.5	0.78	42.0	0.14
Carl Sandburg Home	Cumberland Piedmont	0.42	8.90	176.0	11.00	207.0	5.56	187.0	5.78
Carlsbad Caverns	Chihuahuan Desert	73.12	2.90	101.5	0.90	107.5	1.26	85.0	0.43
Casa Grande Ruins	Sonoran Desert	0.73	3.70	126.5	0.80	96.5	2.47	126.0	0.52
Castillo de San Marcos	Southeast Coast	0.03	8.60	173.5	8.10	186.0	6.93	207.0	5.40
Catoctin Mountain	National Capital Region	8.92	15.40	261.0	17.50	250.0	10.57	254.0	12.15
Cedar Breaks	Northern Colorado Plateau	9.59	3.00	104.5	0.70	84.5	0.65	30.0	0.11
Chaco Culture	Southern Colorado Plateau	53.64	2.20	65.0	0.90	107.5	1.67	108.0	1.15
Channel Islands	Mediterranean Coast	382.75	2.40	75.0	4.90	157.5	10.42	252.0	1.86
Chattahoochee River	Southeast Coast	13.59	13.90	245.5	13.80	230.0	7.23	213.0	9.05
Chesapeake and Ohio Canal	National Capital Region	32.95	12.70	229.5	15.30	241.5	9.73	242.0	15.61
Chickamauga and Chattanooga	Cumberland Piedmont	12.86	13.00	234.0	13.60	228.0	6.99	209.0	7.63
Chickasaw	Southern Plains	15.43	11.10	209.5	5.80	166.0	3.84	151.0	0.55

Park Name	Network Name	Park Area (square miles)	Average N Deposition	Ranking for Average N Deposition	Average S Deposition	Ranking for Average S Deposition	N Emissions by County	Ranking for N Emissions by County	S Emissions by County
Chiricahua	Sonoran Desert	19.01	2.30	69.5	0.70	84.5	0.78	43.0	0.19
City of Rocks	Upper Columbia Basin	22.79	2.60	89.5	0.40	50.5	1.51	95.0	0.14
Colonial	Northeast Coastal and Barrier	14.70	11.40	215.0	17.60	251.0	6.07	196.0	7.20
Colorado	Northern Colorado Plateau	31.90	2.40	75.0	0.70	84.5	0.93	61.0	0.42
Congaree	Southeast Coast	37.89	9.70	189.0	12.10	214.5	4.91	171.0	5.34
Coronado	Sonoran Desert	7.60	2.10	59.0	0.70	84.5	1.19	77.0	0.33
Cowpens	Cumberland Piedmont	1.31	9.70	189.0	12.30	218.0	5.36	183.0	5.38
Crater Lake	Klamath	284.04	2.70	94.0	0.70	84.5	1.72	112.0	0.26
Craters of the Moon	Upper Columbia Basin	733.96	2.60	89.5	0.30	41.0	1.36	89.0	0.22
Cumberland Gap	Cumberland Piedmont	38.84	10.70	204.0	12.50	220.5	3.88	153.0	5.28
Cumberland Island	Southeast Coast	56.92	6.10	156.0	8.40	188.5	5.18	178.0	3.82
Curecanti	Northern Colorado Plateau	64.08	2.00	52.5	0.60	74.5	0.90	57.0	0.19
Cuyahoga Valley	Heartland	52.21	21.70	271.0	21.10	260.0	10.67	257.0	18.25
Death Valley	Mojave Desert	5314.15	1.80	43.5	0.20	36.0	2.15	122.0	0.53
Delaware Water Gap	Eastern Rivers and Mountains	107.20	11.60	218.0	13.30	226.0	11.97	263.0	9.05
Denali	Central Alaska	9416.92	No Data		No Data		0.41	18.0	0.09
Devils Postpile	Sierra Nevada	1.25	2.20	65.0	0.70	84.5	2.31	124.0	0.18
Devils Tower	Northern Great Plains	2.11	3.10	107.0	1.10	120.0	0.68	33.0	0.39
Dinosaur	Northern Colorado Plateau	329.42	2.10	59.0	0.50	63.0	1.25	82.0	0.81
Dry Tortugas	South Florida Caribbean	102.47	No Data		No Data		6.09	197.0	2.85
Ebey's Landing	North Coast and Cascades	27.90	2.10	59.0	4.10	156.0	3.90	154.0	0.92

Park Name	Network Name	Park Area (square miles)	Average N Deposition	Ranking for Average N Deposition	Average S Deposition	Ranking for Average S Deposition	N Emissions by County	Ranking for N Emissions by County	S Emissions by County
Effigy Mounds	Heartland	3.88	11.60	218.0	5.40	163.0	5.85	190.0	2.34
Eisenhower	Mid Atlantic	1.09	15.30	260.0	15.30	241.5	10.97	260.0	13.95
El Malpais	Southern Colorado Plateau	182.63	2.20	65.0	0.90	107.5	1.22	80.0	0.72
El Morro	Southern Colorado Plateau	2.00	2.50	83.0	1.10	120.0	1.36	90.0	0.93
Everglades	South Florida Caribbean	2404.11	5.70	152.5	5.00	159.0	6.64	202.0	3.57
Fire Island	Northeast Coastal and Barrier	30.72	12.40	226.5	15.80	246.0	16.81	271.0	9.04
Florissant Fossil Beds	Rocky Mountain	9.36	3.30	114.0	1.30	127.0	2.48	127.0	1.29
Fort Bowie	Sonoran Desert	1.56	2.30	69.5	0.80	96.5	0.79	44.0	0.20
Fort Caroline	Southeast Coast	0.22	11.90	221.5	16.40	247.0	5.28	181.0	3.55
Fort Davis	Chihuahuan Desert	0.81	2.40	75.0	0.90	107.5	0.64	29.0	0.18
Fort Donelson	Cumberland Piedmont	0.86	12.60	228.0	13.10	223.5	6.50	200.0	7.53
Fort Frederica	Southeast Coast	0.44	9.70	189.0	9.00	192.0	4.51	165.0	3.21
Fort Laramie	Northern Great Plains	1.33	3.50	121.0	0.80	96.5	1.72	111.0	0.68
Fort Larned	Southern Plains	1.10	8.60	173.5	1.60	131.5	3.02	133.0	0.37
Fort Matanzas	Southeast Coast	0.47	9.10	177.5	8.30	187.0	7.79	218.0	6.73
Fort Necessity	Eastern Rivers and Mountains	1.44	15.00	258.0	48.50	270.0	8.86	233.0	23.74
Fort Point	San Francisco Bay Area	0.04	2.30	69.5	3.30	146.5	10.80	259.0	2.05
Fort Pulaski	Southeast Coast	8.66	7.10	162.0	12.20	216.5	3.38	138.0	3.44
Fort Sumter	Southeast Coast	0.36	No Data		No Data		5.36	182.0	7.87
Fort Union	Southern Plains	1.13	2.40	75.0	0.70	84.5	0.62	27.0	0.05
Fort Union Trading Post	Northern Great Plains	0.72	3.30	114.0	1.50	130.0	0.79	46.0	0.52

Park Name	Network Name	Park Area (square miles)	Average N Deposition	Ranking for Average N Deposition	Average S Deposition	Ranking for Average S Deposition	N Emissions by County	Ranking for N Emissions by County	S Emissions by County
Fort Vancouver	North Coast and Cascades	0.34	7.60	167.0	4.00	154.0	3.59	144.0	0.96
Fossil Butte	Northern Colorado Plateau	13.00	2.40	75.0	0.70	84.5	1.57	98.0	1.15
Fredericksburg and Spotsylvania	Mid Atlantic	16.22	11.40	215.0	12.00	213.0	8.66	230.0	9.71
Friendship Hill	Eastern Rivers and Mountains	1.03	13.00	234.0	56.60	271.0	8.97	234.0	25.90
Gates of the Arctic	Arctic	13237.86	No Data		No Data		0.37	17.0	0.06
Gateway	Northeast Coastal and Barrier	42.16	14.00	247.0	21.30	262.0	16.12	269.0	10.19
Gauley River	Eastern Rivers and Mountains	17.43	11.70	220.0	18.50	255.0	5.41	184.0	11.29
George Washington	National Capital Region	10.49	16.20	265.0	21.70	263.0	10.38	250.0	11.29
George Washington Birthplace	Northeast Coastal and Barrier	0.70	13.20	240.0	18.40	253.5	10.10	247.0	12.21
George Washington Carver	Heartland	0.33	12.30	225.0	6.50	174.5	5.18	176.0	2.51
Gettysburg	Mid Atlantic	9.32	15.50	262.0	15.40	244.0	11.08	261.0	14.08
Gila Cliff Dwellings	Sonoran Desert	0.95	2.50	83.0	0.80	96.5	0.47	20.0	0.16
Glacier	Rocky Mountain	1575.11	4.30	133.0	1.30	127.0	0.63	28.0	0.06
Glacier Bay	Southeast Alaska	5130.87	No Data		No Data		0.04	8.0	0.02
Glen Canyon	Southern Colorado Plateau	1954.63	1.80	43.5	0.30	41.0	1.13	74.0	0.72
Golden Gate	San Francisco Bay Area	122.52	4.70	140.0	4.00	154.0	8.53	228.0	1.56
Golden Spike	Northern Colorado Plateau	4.17	3.20	110.0	0.60	74.5	1.69	109.0	0.59

Park Name	Network Name	Park Area (square miles)	Average N Deposition	Ranking for Average N Deposition	Average S Deposition	Ranking for Average S Deposition	N Emissions by County	Ranking for N Emissions by County	S Emissions by County
Grand Canyon	Southern Colorado Plateau	1886.97	2.20	65.0	0.50	63.0	1.10	72.0	0.62
Grand Portage	Great Lakes	1.11	3.10	107.0	1.60	131.5	0.53	24.0	0.33
Grand Teton	Greater Yellowstone	484.40	4.50	134.5	1.30	127.0	0.75	40.0	0.38
Grant-Kohrs Ranch	Rocky Mountain	2.47	1.80	43.5	0.30	41.0	0.55	25.0	0.06
Great Basin	Mojave Desert	120.31	1.60	36.0	0.30	41.0	0.56	26.0	0.09
Great Sand Dunes	Rocky Mountain	191.54	2.00	52.5	0.40	50.5	0.98	64.0	0.56
Great Smoky Mountains	Appalachian Highlands	810.14	9.60	185.5	11.40	209.5	5.25	179.0	6.12
Guadalupe Mountains	Chihuahuan Desert	137.32	2.70	94.0	0.80	96.5	1.13	75.0	0.39
Guilford Courthouse	Cumberland Piedmont	0.34	12.40	226.5	13.70	229.0	6.86	204.0	8.03
Gulf Islands	Gulf Coast	188.25	6.50	158.0	11.00	207.0	5.94	194.0	4.93
Hagerman Fossil Beds	Upper Columbia Basin	6.74	5.10	144.0	0.30	41.0	1.63	103.0	0.10
Haleakala	Pacific Island	45.72	No Data		No Data		1.21	79.0	1.04
Harpers Ferry	National Capital Region	5.80	13.10	238.0	15.30	241.5	9.67	241.0	10.05
Hawaii Volcanoes	Pacific Island	558.42	No Data		No Data		0.88	54.0	0.81
Herbert Hoover	Heartland	0.29	13.00	234.0	7.50	184.0	5.87	192.0	2.97
Home of Franklin D. Roosevelt	Northeast Temperate	1.40	11.30	212.0	14.20	233.0	10.12	248.0	5.90
Homestead	Heartland	0.35	12.70	229.5	5.40	163.0	4.80	170.0	2.71
Hopewell Culture	Heartland	1.75	13.90	245.5	29.50	267.0	9.49	239.0	20.50
Hopewell Furnace	Mid Atlantic	1.33	16.50	267.5	18.40	253.5	14.18	266.0	13.32
Horseshoe Bend	Southeast Coast	3.20	9.60	185.5	9.70	197.0	5.96	195.0	9.64
Hot Springs	Heartland	8.53	9.20	179.5	6.30	173.0	3.25	135.0	1.15
Hovenweep	Northern Colorado Plateau	1.26	2.50	83.0	1.00	115.5	1.46	93.0	1.10

Park Name	Network Name	Park Area (square miles)	Average N Deposition	Ranking for Average N Deposition	Average S Deposition	Ranking for Average S Deposition	N Emissions by County	Ranking for N Emissions by County	S Emissions by County
Hubbell Trading Post	Southern Colorado Plateau	0.25	2.00	52.5	0.50	63.0	1.90	116.0	1.59
Indiana Dunes	Great Lakes	24.78	14.10	248.5	24.20	266.0	9.18	236.0	5.54
Isle Royale	Great Lakes	858.95	3.00	104.5	2.30	138.0	0.41	19.0	0.35
Jean Lafitte	Gulf Coast	29.11	10.20	194.5	10.60	203.0	6.87	205.0	5.07
Jewel Cave	Northern Great Plains	1.95	3.50	121.0	1.00	115.5	0.79	45.0	0.47
John Day Fossil Beds	Upper Columbia Basin	21.83	1.60	36.0	0.30	41.0	1.40	91.0	0.30
John Muir	San Francisco Bay Area	0.54	8.00	169.5	5.30	161.0	9.22	237.0	1.68
Johnstown Flood	Eastern Rivers and Mountains	0.27	14.70	255.0	34.60	269.0	8.18	225.0	19.96
Joshua Tree	Mojave Desert	1238.97	4.60	137.0	0.40	50.5	4.55	166.0	0.58
Kalaupapa	Pacific Island	16.63	No Data		No Data		8.16	222.0	6.53
Kaloko-Honokohau	Pacific Island	1.99	No Data		No Data		1.01	68.0	0.89
Katmai	Southwest Alaska	6405.79	No Data		No Data		0.05	10.0	0.00
Kenai Fjords	Southwest Alaska	1042.70	No Data		No Data		0.47	22.0	0.09
Kennesaw Mountain	Southeast Coast	4.53	15.20	259.0	17.40	249.0	8.17	224.0	10.53
Kings Canyon	Sierra Nevada	717.11	2.60	89.5	0.70	84.5	2.42	125.0	0.18
Kings Mountain	Cumberland Piedmont	6.19	10.40	197.5	12.80	222.0	5.59	188.0	5.78
Klondike Gold Rush	Southeast Alaska	20.30	No Data		No Data		0.04	9.0	0.02
Knife River Indian Villages	Northern Great Plains	2.79	4.70	140.0	3.70	151.0	1.88	115.0	2.69
Kobuk Valley	Arctic	2737.18	No Data		No Data		0.16	13.0	0.02
Lake Clark	Southwest Alaska	6303.97	No Data		No Data		0.18	15.0	0.03
Lake Mead	Mojave Desert	2332.47	2.50	83.0	0.50	63.0	1.08	71.0	0.40
Lake Meredith	Southern Plains	65.04	7.20	164.0	7.10	181.0	3.40	139.0	1.23
Lake Roosevelt	Upper Columbia Basin	163.61	1.90	47.5	0.50	63.0	1.21	78.0	0.11

Park Name	Network Name	Park Area (square miles)	Average N Deposition	Ranking for Average N Deposition	Average S Deposition	Ranking for Average S Deposition	N Emissions by County	Ranking for N Emissions by County	S Emissions by County
Lassen Volcanic	Klamath	167.66	3.40	118.0	1.00	115.5	0.91	58.0	0.16
Lava Beds	Klamath	72.94	1.80	43.5	0.30	41.0	0.93	60.0	0.13
Lewis and Clark	North Coast and Cascades	5.58	4.50	134.5	4.00	154.0	4.17	158.0	1.19
Lincoln Boyhood	Heartland	0.31	14.10	248.5	20.50	259.0	8.01	219.0	15.44
Little Bighorn Battlefield	Rocky Mountain	1.22	2.40	75.0	0.70	84.5	0.95	62.0	0.64
Little River Canyon	Cumberland Piedmont	21.37	13.10	238.0	14.90	239.0	8.02	220.0	10.72
Lyndon B. Johnson	Southern Plains	2.62	8.00	169.5	3.40	148.0	3.56	141.0	2.41
Mammoth Cave	Cumberland Piedmont	80.77	13.00	234.0	13.90	231.5	7.20	211.0	11.37
Manassas	National Capital Region	8.01	14.40	252.0	13.90	231.5	9.66	240.0	10.75
Manzanar	Mojave Desert	1.27	1.70	39.5	0.10	35.0	2.27	123.0	0.18
Marsh-Billings-Rockefeller	Northeast Temperate	1.00	7.50	166.0	6.70	176.0	3.19	134.0	1.96
Mesa Verde	Southern Colorado Plateau	83.88	3.20	110.0	1.10	120.0	1.50	94.0	1.14
Minute Man	Northeast Temperate	1.49	10.70	204.0	10.90	205.0	8.05	221.0	5.95
Mississippi	Great Lakes	84.11	14.60	254.0	9.60	196.0	5.86	191.0	1.63
Missouri	Northern Great Plains	107.87	10.10	193.0	2.60	140.5	4.45	163.0	0.79
Mojave	Mojave Desert	2483.03	3.40	118.0	0.40	50.5	1.97	117.0	0.66
Monocacy	National Capital Region	2.53	14.20	250.0	19.60	258.0	10.64	256.0	11.30
Montezuma Castle	Sonoran Desert	1.33	2.60	89.5	0.50	63.0	1.83	113.0	0.55
Moores Creek	Southeast Coast	0.16	16.00	264.0	9.30	195.0	8.17	223.0	3.55
Morristown	Northeast Temperate	2.67	14.40	252.0	14.50	234.0	14.66	267.0	9.14
Mount Rainier	North Coast and Cascades	367.56	4.90	142.0	2.70	142.5	3.71	147.0	0.82

Park Name	Network Name	Park Area (square miles)	Average N Deposition	Ranking for Average N Deposition	Average S Deposition	Ranking for Average S Deposition	N Emissions by County	Ranking for N Emissions by County	S Emissions by County
Mount Rushmore	Northern Great Plains	2.02	3.80	129.5	1.00	115.5	0.67	32.0	0.28
Muir Woods	San Francisco Bay Area	0.90	5.30	145.5	6.10	169.5	10.71	258.0	2.06
Natchez Trace Parkway and National Scenic Trail	Gulf Coast	71.52	10.80	206.0	9.00	192.0	4.58	167.0	3.78
National Capital Parks - East	National Capital Region	5.94	16.50	267.5	22.80	264.0	11.14	262.0	11.24
National Park of American Samoa	Pacific Island	16.66	No Data		No Data		No Data		No Data
Natural Bridges	Northern Colorado Plateau	11.56	2.00	52.5	0.60	74.5	0.93	59.0	0.66
Navajo	Southern Colorado Plateau	0.56	1.70	39.5	0.30	41.0	1.11	73.0	0.78
New River Gorge	Eastern Rivers and Mountains	109.98	11.30	212.0	16.70	248.0	5.10	175.0	9.83
Nez Perce	Upper Columbia Basin	5.39	2.50	83.0	0.50	63.0	0.86	51.0	0.12
Ninety Six	Cumberland Piedmont	1.50	9.20	179.5	9.00	192.0	5.18	177.0	4.87
Niobrara	Northern Great Plains	45.47	5.90	154.5	1.20	123.0	1.57	99.0	0.05
Noatak	Arctic	10280.90	No Data		No Data		0.16	14.0	0.02
North Cascades	North Coast and Cascades	782.91	3.80	129.5	2.70	142.5	2.82	131.0	0.64
Obed	Appalachian Highlands	8.32	12.00	223.5	14.60	235.0	4.48	164.0	4.64
Ocmulgee	Southeast Coast	1.08	10.50	200.5	11.60	211.0	5.67	189.0	6.39
Olympic	North Coast and Cascades	1428.42	3.80	129.5	3.60	150.0	4.19	159.0	1.27
Oregon Caves	Klamath	0.73	2.80	98.0	1.00	115.5	2.09	120.0	0.34
Organ Pipe Cactus	Sonoran Desert	516.70	1.70	39.5	0.50	63.0	2.60	128.0	0.21
Ozark	Heartland	128.62	9.30	182.0	7.20	182.0	3.92	155.0	3.52

Park Name	Network Name	Park Area (square miles)	Average N Deposition	Ranking for Average N Deposition	Average S Deposition	Ranking for Average S Deposition	N Emissions by County	Ranking for N Emissions by County	S Emissions by County
Padre Island	Gulf Coast	204.94	5.40	148.5	5.80	166.0	3.77	149.0	1.01
Palo Alto Battlefield	Gulf Coast	5.33	5.40	148.5	3.50	149.0	3.56	142.0	0.29
Pea Ridge	Heartland	6.67	16.60	269.0	6.10	169.5	5.00	174.0	2.40
Pecos	Southern Plains	10.20	3.10	107.0	0.90	107.5	0.89	55.0	0.09
Petersburg	Mid Atlantic	5.24	13.70	242.5	15.50	245.0	5.92	193.0	8.14
Petrified Forest	Southern Colorado Plateau	348.43	2.50	83.0	0.90	107.5	1.25	83.0	1.13
Petroglyph	Southern Colorado Plateau	11.25	3.70	126.5	0.70	84.5	1.01	67.0	0.19
Pictured Rocks	Great Lakes	115.12	8.70	175.0	6.20	171.5	0.70	35.0	0.65
Pinnacles	San Francisco Bay Area	42.42	5.00	143.0	1.20	123.0	6.82	203.0	1.00
Pipe Spring	Northern Colorado Plateau	0.06	2.10	59.0	0.40	50.5	0.73	38.0	0.23
Pipestone	Heartland	0.44	14.80	256.5	3.30	146.5	5.28	180.0	0.49
Point Reyes	San Francisco Bay Area	112.29	5.40	148.5	3.80	152.0	9.78	243.0	1.90
Prince William Forest	National Capital Region	17.33	13.10	238.0	14.70	237.0	9.83	244.0	11.36
Pu'uhonua o Honaunau	Pacific Island	0.66	No Data		No Data		0.86	53.0	0.80
Puukohola Heiau	Pacific Island	0.13	No Data		No Data		1.04	70.0	0.92
Rainbow Bridge	Southern Colorado Plateau	0.25	1.90	47.5	0.30	41.0	0.74	39.0	0.41
Redwood	Klamath	180.69	2.90	101.5	2.00	135.5	1.98	118.0	0.32
Richmond	Mid Atlantic	2.37	13.00	234.0	24.10	265.0	6.92	206.0	7.84
Rock Creek Park	National Capital Region	4.23	16.40	266.0	21.20	261.0	10.61	255.0	11.31
Rocky Mountain	Rocky Mountain	417.06	4.20	132.0	1.20	123.0	2.92	132.0	1.08

Park Name	Network Name	Park Area (square miles)	Average N Deposition	Ranking for Average N Deposition	Average S Deposition	Ranking for Average S Deposition	N Emissions by County	Ranking for N Emissions by County	S Emissions by County
Russell Cave	Cumberland Piedmont	0.50	12.00	223.5	13.30	226.0	6.11	198.0	7.45
Sagamore Hill	Northeast Coastal and Barrier	0.11	No Data		No Data		15.36	268.0	9.11
Saguaro	Sonoran Desert	146.02	2.80	98.0	0.80	96.5	1.66	105.0	0.35
Saint Croix	Great Lakes	152.70	10.00	191.5	4.90	157.5	4.07	157.0	1.36
Saint-Gaudens	Northeast Temperate	0.23	7.30	165.0	6.80	177.5	3.83	150.0	2.39
Salinas Pueblo Missions	Southern Colorado Plateau	1.66	2.50	83.0	0.60	74.5	0.81	48.0	0.07
San Antonio Missions	Gulf Coast	1.29	10.90	207.0	7.00	180.0	3.60	146.0	1.72
San Juan Island	North Coast and Cascades	2.69	No Data		No Data		3.86	152.0	1.04
Santa Monica Mountains	Mediterranean Coast	234.38	10.40	197.5	2.60	140.5	8.60	229.0	1.45
Saratoga	Northeast Temperate	4.49	10.30	196.0	10.00	199.0	3.34	137.0	1.84
Saugus Iron Works	Northeast Temperate	0.02	No Data		No Data		8.68	231.0	6.68
Scotts Bluff	Northern Great Plains	5.06	5.50	151.0	0.90	107.5	2.14	121.0	0.43
Sequoia	Sierra Nevada	635.63	3.80	129.5	0.70	84.5	2.65	129.0	0.21
Shenandoah	Mid Atlantic	301.99	13.70	242.5	12.10	214.5	6.95	208.0	8.05
Shiloh	Cumberland Piedmont	6.38	11.30	212.0	10.40	202.0	4.30	161.0	4.35
Sitka	Southeast Alaska	0.18	No Data		No Data		0.03	5.0	0.01
Sleeping Bear Dunes	Great Lakes	109.72	9.30	182.0	6.80	177.5	1.65	104.0	1.16
Stones River	Cumberland Piedmont	1.11	11.90	221.5	12.50	220.5	5.44	186.0	5.97
Sunset Crater Volcano	Southern Colorado Plateau	4.75	2.70	94.0	0.40	50.5	1.25	84.0	0.58
Tallgrass Prairie	Heartland	17.09	11.60	218.0	5.40	163.0	4.63	168.0	2.73
Theodore Roosevelt	Northern Great Plains	109.97	3.60	124.0	1.90	134.0	1.32	87.0	1.80
Thomas Stone	Northeast Coastal and Barrier	0.51	13.80	244.0	17.90	252.0	10.40	251.0	12.53

Park Name	Network Name	Park Area (square miles)	Average N Deposition	Ranking for Average N Deposition	Average S Deposition	Ranking for Average S Deposition	N Emissions by County	Ranking for N Emissions by County	S Emissions by County
Timpanogos Cave	Northern Colorado Plateau	0.39	5.70	152.5	1.30	127.0	1.67	107.0	0.57
Timucaun Ecological and Historical Preserve	Southeast Coast	71.40	10.50	200.5	11.90	212.0	4.93	172.0	3.11
Tonto	Sonoran Desert	1.75	3.50	121.0	0.60	74.5	2.02	119.0	0.69
Tumacacori	Sonoran Desert	0.57	2.20	65.0	0.60	74.5	1.42	92.0	0.33
Tuzigoot	Sonoran Desert	1.27	2.50	83.0	0.50	63.0	1.63	102.0	0.42
Upper Delaware	Eastern Rivers and Mountains	86.17	10.00	191.5	10.80	204.0	9.33	238.0	7.26
Valley Forge	Mid Atlantic	5.39	15.80	263.0	18.90	256.0	16.18	270.0	14.66
Vanderbilt Mansion	Northeast Temperate	0.33	10.50	200.5	12.20	216.5	9.99	245.0	5.79
Vicksburg	Gulf Coast	2.58	9.30	182.0	6.20	171.5	3.60	145.0	0.73
Virgin Islands	South Florida Caribbean	23.07	No Data		No Data		8.36	226.0	3.06
Voyageurs	Great Lakes	320.18	4.60	137.0	2.00	135.5	1.55	97.0	1.02
Walnut Canyon	Southern Colorado Plateau	5.58	2.70	94.0	0.60	74.5	1.34	88.0	0.62
War in the Pacific	Pacific Island	2.98	No Data		No Data		No Data		No Data
Washita Battlefield	Southern Plains	0.49	8.40	172.0	2.20	137.0	2.70	130.0	0.56
Weir Farm	Northeast Temperate	0.09	14.80	256.5	14.70	237.0	13.20	265.0	7.57
Whiskeytown	Klamath	65.84	5.30	145.5	1.70	133.0	0.86	52.0	0.13
White Sands	Chihuahuan Desert	227.32	2.00	52.5	0.50	63.0	0.89	56.0	0.15
Whitman Mission	Upper Columbia Basin	0.16	3.30	114.0	0.80	96.5	1.66	106.0	0.35
Wilson's Creek	Heartland	3.73	10.20	194.5	6.50	174.5	3.58	143.0	1.13
Wind Cave	Northern Great Plains	44.26	3.30	114.0	1.00	115.5	0.80	47.0	0.35
Wolf Trap National Park for the Performing Arts	National Capital Region	0.21	16.80	270.0	19.40	257.0	10.51	253.0	11.60

Park Name	Network Name	Park Area (square miles)	Average N Deposition	Ranking for Average N Deposition	Average S Deposition	Ranking for Average S Deposition	N Emissions by County	Ranking for N Emissions by County	S Emissions by County
Wrangell-St. Elias	Central Alaska	20588.98	No Data		No Data		0.11	12.0	0.03
Wupatki	Southern Colorado Plateau	55.39	1.90	47.5	0.40	50.5	1.27	86.0	0.63
Yellowstone	Greater Yellowstone	3436.65	3.40	118.0	0.80	96.5	0.68	34.0	0.24
Yosemite	Sierra Nevada	1164.65	2.90	101.5	0.90	107.5	3.95	156.0	0.46
Yucca House	Southern Colorado Plateau	0.06	No Data		No Data		1.61	100.0	1.27
Yukon-Charley Rivers	Central Alaska	3940.33	No Data		No Data		0.47	21.0	0.12
Zion	Northern Colorado Plateau	232.40	2.70	94.0	0.50	63.0	0.71	37.0	0.24

Table A-2. Ecosystem Sensitivity Variables

Park Name	Network Name	Park Area (square miles)	Percent Sensitive Vegetation Types	Ranking for Percent Sensitive Vegetation Types	Number of High Elevation Lakes	Ranking for Number of High Elevation Lakes	Kilometers of High Elevation Streams	Ranking for Kilometers of High Elevation Streams	Stream Order 1 - 3	Ranking for Stream Order 1 - 3	Sensitive Areas	Ranking for Sensitive Areas	Slope (degrees)	Ranking of Slope (degrees)
Abraham Lincoln Birthplace	Cumberland Piedmont	0.53	4.26	224.0	0	126.0	0.00	96.5	2.37	111.0	1	1.0	9.83	145.0
Acadia	Northeast Temperate	60.61	71.94	271.0	0	126.0	0.00	96.5	88.72	205.0	5	271.0	17.81	188.0
Agate Fossil Beds	Northern Great Plains	4.76	0.00	101.0	0	126.0	20.22	229.0	6.81	145.0	1	1.0	6.25	110.0
Alagnak	Southwest Alaska	48.29	0.00	101.0	0	126.0	0.00	96.5	No Data		No Data		1.76	38.0
Alibates Flint Quarries	Southern Plains	2.14	0.00	101.0	0	126.0	0.00	96.5	2.20	109.0	1	1.0	9.80	144.0
Allegheny Portage Railroad	Eastern Rivers and Mountains	1.67	71.43	270.0	0	126.0	0.34	193.0	4.90	135.0	5	271.0	20.91	204.0
American Memorial Park	Pacific Island	0.21	0.00	101.0	0	126.0	No Data		No Data		No Data		No Data	
Amistad	Chihuahuan Desert	89.95	0.00	101.0	0	126.0	0.00	96.5	108.33	212.0	1	1.0	3.11	55.0
Aniakchak	Southwest Alaska	942.86	0.00	101.0	0	126.0	0.69	198.0	No Data		No Data		8.49	132.0
Antietam	National Capital Region	5.08	3.53	219.0	0	126.0	0.00	96.5	7.64	148.0	5	271.0	5.34	98.0
Apostle Islands	Great Lakes	107.42	39.88	259.0	0	126.0	0.00	96.5	6.11	141.0	5	271.0	4.84	90.0
Appomattox Court House	Mid Atlantic	2.78	0.00	101.0	0	126.0	0.00	96.5	4.73	131.0	1	1.0	5.82	103.5
Arches	Northern Colorado Plateau	119.47	0.00	101.0	0	126.0	0.00	96.5	129.22	219.0	1	1.0	15.09	173.0
Arkansas Post	Heartland	0.66	0.00	101.0	0	126.0	0.00	96.5	1.37	94.0	1	1.0	1.09	33.0

Park Name	Network Name	Park Area (square miles)	Percent Sensitive Vegetation Types	Ranking for Percent Sensitive Vegetation Types	Number of High Elevation Lakes	Ranking for Number of High Elevation Lakes	Kilometers of High Elevation Streams	Ranking for Kilometers of High Elevation Streams	Stream Order 1 - 3	Ranking for Stream Order 1 - 3	Sensitive Areas	Ranking for Sensitive Areas	Slope (degrees)	Ranking of Slope (degrees)
Assateague Island	Northeast Coastal and Barrier	76.15	0.00	101.0	0	126.0	0.00	96.5	0.00	40.0	1	1.0	0.30	17.0
Aztec Ruins	Southern Colorado Plateau	0.49	0.00	101.0	0	126.0	0.00	96.5	0.00	40.0	1	1.0	8.91	136.0
Badlands	Northern Great Plains	379.27	0.00	101.0	0	126.0	0.00	96.5	1127.74	257.0	1	1.0	7.13	116.0
Bandelier	Southern Colorado Plateau	52.80	0.00	101.0	0	126.0	15.05	225.0	125.38	216.0	1	1.0	23.44	213.0
Bent's Old Fort	Southern Plains	1.25	0.00	101.0	0	126.0	0.00	96.5	0.00	40.0	1	1.0	1.47	36.0
Bering Land Bridge	Arctic	4351.17	0.00	101.0	0	126.0	7.24	219.0	No Data		No Data		1.95	39.0
Big Bend	Chihuahuan Desert	1270.68	0.00	101.0	0	126.0	44.16	236.0	2163.52	265.0	1	1.0	14.76	172.0
Big Cypress	South Florida Caribbean	1139.86	0.00	101.0	0	126.0	0.00	96.5	26.01	179.0	1	1.0	0.02	5.0
Big Hole	Upper Columbia Basin	1.05	0.00	101.0	0	126.0	0.00	96.5	2.79	121.0	1	1.0	21.92	208.0
Big South Fork	Appalachian Highlands	191.41	20.57	245.0	0	126.0	0.00	96.5	365.40	242.0	5	271.0	15.11	174.0
Big Thicket	Gulf Coast	138.78	0.00	101.0	0	126.0	0.00	96.5	203.68	229.0	1	1.0	1.16	34.0
Bighorn Canyon	Greater Yellowstone	186.79	0.00	101.0	0	126.0	0.00	96.5	349.48	241.0	1	1.0	20.31	202.0
Biscayne	South Florida Caribbean	274.36	0.00	101.0	0	126.0	0.00	96.5	2.56	113.0	1	1.0	0.06	8.0
Black Canyon of the Gunnison	Northern Colorado Plateau	48.99	0.00	101.0	0	126.0	0.34	194.0	38.58	187.0	1	1.0	35.61	257.0
Blue Ridge	Appalachian Highlands	141.45	7.77	232.0	3	259.0	78.79	243.0	217.41	233.0	5	271.0	26.35	231.0

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Bluestone	Eastern Rivers and Mountains	6.78	33.63	253.0	0	126.0	1.65	207.0	7.41	147.0	5	271.0	38.67	259.0
Booker T. Washington	Mid Atlantic	0.37	0.00	101.0	0	126.0	0.00	96.5	0.98	86.0	1	1.0	5.17	92.0
Boston Harbor Islands	Northeast Temperate	2.49	13.97	236.0	0	126.0	0.00	96.5	0.05	62.0	1	1.0	3.14	56.0
Bryce Canyon	Northern Colorado Plateau	56.23	0.00	101.0	0	126.0	4.05	213.0	98.56	210.0	1	1.0	25.76	228.0
Buck Island Reef	South Florida Caribbean	29.67	0.00	101.0	0	126.0	0.00	96.5	0.00	40.0	No Data		0.09	9.0
Buffalo	Heartland	146.16	0.00	101.0	1	255.0	32.35	233.0	214.78	232.0	1	1.0	23.01	210.0
Cabrillo	Mediterranean Coast	0.25	0.00	101.0	0	126.0	0.00	96.5	0.00	40.0	1	1.0	25.00	224.0
Canaveral	Southeast Coast	91.34	0.00	101.0	0	126.0	0.00	96.5	29.19	182.0	1	1.0	0.28	16.0
Canyon de Chelly	Southern Colorado Plateau	144.62	0.00	101.0	0	126.0	0.00	96.5	247.81	239.0	1	1.0	22.64	209.0
Canyonlands	Northern Colorado Plateau	523.32	0.00	101.0	0	126.0	0.00	96.5	817.07	253.0	1	1.0	25.08	226.0
Cape Cod	Northeast Coastal and Barrier	63.35	0.80	212.0	0	126.0	0.00	96.5	11.69	158.0	5	271.0	2.84	52.0
Cape Hatteras	Southeast Coast	48.58	0.00	101.0	0	126.0	0.00	96.5	6.37	142.0	1	1.0	0.28	15.0
Cape Krusenstern	Arctic	1031.23	0.00	101.0	0	126.0	0.00	96.5	No Data		No Data		2.80	51.0
Cape Lookout	Southeast Coast	43.66	0.00	101.0	0	126.0	0.00	96.5	0.26	71.0	1	1.0	0.19	12.0
Capitol Reef	Northern Colorado Plateau	381.42	0.00	101.0	0	126.0	0.01	190.0	659.43	249.0	1	1.0	23.77	214.0
Capulin Volcano	Southern Plains	1.24	0.00	101.0	0	126.0	0.00	96.5	0.00	40.0	1	1.0	35.16	251.0

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Carl Sandburg Home	Cumberland Piedmont	0.42	0.00	101.0	1	255.0	0.64	197.0	0.65	81.0	5	271.0	19.92	198.0
Carlsbad Caverns	Chihuahuan Desert	73.12	0.00	101.0	0	126.0	96.58	247.0	227.95	235.0	1	1.0	27.30	234.0
Casa Grande Ruins	Sonoran Desert	0.73	0.00	101.0	0	126.0	0.00	96.5	0.00	40.0	1	1.0	0.56	25.0
Castillo de San Marcos	Southeast Coast	0.03	0.00	101.0	0	126.0	0.00	96.5	0.00	40.0	1	1.0	0.17	11.0
Catoctin Mountain	National Capital Region	8.92	37.92	256.0	0	126.0	4.68	214.0	8.27	152.0	5	271.0	23.21	211.0
Cedar Breaks	Northern Colorado Plateau	9.59	0.00	101.0	0	126.0	14.77	224.0	17.90	168.0	1	1.0	35.59	256.0
Chaco Culture	Southern Colorado Plateau	53.64	0.00	101.0	0	126.0	0.00	96.5	58.23	196.0	1	1.0	11.77	156.0
Channel Islands	Mediterranean Coast	382.75	0.00	101.0	0	126.0	0.00	96.5	513.57	246.0	1	1.0	23.33	212.0
Chattahoochee River	Southeast Coast	13.59	0.00	101.0	0	126.0	92.68	246.0	16.12	165.0	1	1.0	7.97	126.0
Chesapeake and Ohio Canal	National Capital Region	32.95	15.61	239.0	0	126.0	0.00	96.5	23.63	175.0	5	271.0	12.80	163.0
Chickamauga and Chattanooga	Cumberland Piedmont	12.86	14.59	237.0	0	126.0	1.12	205.0	25.59	178.0	5	271.0	15.93	180.0
Chickasaw	Southern Plains	15.43	0.00	101.0	0	126.0	0.00	96.5	22.98	173.0	1	1.0	5.32	97.0
Chiricahua	Sonoran Desert	19.01	0.00	101.0	0	126.0	40.41	234.0	49.15	192.0	1	1.0	31.82	246.0
City of Rocks	Upper Columbia Basin	22.79	0.00	101.0	0	126.0	11.32	223.0	48.80	191.0	1	1.0	26.32	230.0
Colonial	Northeast Coastal and Barrier	14.70	0.00	101.0	0	126.0	0.00	96.5	19.02	169.0	1	1.0	2.05	41.0

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Colorado	Northern Colorado Plateau	31.90	0.00	101.0	0	126.0	0.00	96.5	72.36	201.0	1	1.0	29.91	241.0
Congaree	Southeast Coast	37.89	0.00	101.0	0	126.0	0.00	96.5	31.49	184.0	1	1.0	0.46	19.0
Coronado	Sonoran Desert	7.60	0.00	101.0	0	126.0	0.00	96.5	0.00	40.0	1	1.0	35.33	254.0
Cowpens	Cumberland Piedmont	1.31	0.00	101.0	0	126.0	0.00	96.5	1.52	96.0	1	1.0	3.38	60.0
Crater Lake	Klamath	284.04	0.00	101.0	1	255.0	145.77	254.0	206.81	230.0	1	1.0	18.69	191.0
Craters of the Moon	Upper Columbia Basin	733.96	0.00	101.0	0	126.0	0.00	96.5	1.40	95.0	1	1.0	2.78	49.5
Cumberland Gap	Cumberland Piedmont	38.84	54.09	267.0	0	126.0	53.66	239.0	57.21	194.0	5	271.0	31.09	244.0
Cumberland Island	Southeast Coast	56.92	0.00	101.0	0	126.0	0.00	96.5	81.30	204.0	1	1.0	0.59	26.0
Curecanti	Northern Colorado Plateau	64.08	0.00	101.0	1	255.0	1.42	206.0	68.48	199.0	1	1.0	29.95	243.0
Cuyahoga Valley	Heartland	52.21	53.09	266.0	0	126.0	0.00	96.5	183.09	226.0	1	1.0	8.27	128.0
Death Valley	Mojave Desert	5314.15	0.00	101.0	0	126.0	215.20	257.0	5675.07	271.0	1	1.0	23.83	215.0
Delaware Water Gap	Eastern Rivers and Mountains	107.20	37.94	257.0	0	126.0	0.00	96.5	143.12	221.0	5	271.0	18.93	194.0
Denali	Central Alaska	9416.92	0.00	101.0	0	126.0	499.20	262.0	No Data		No Data		10.31	147.0
Devils Postpile	Sierra Nevada	1.25	0.00	101.0	0	126.0	2.44	210.0	4.80	133.0	1	1.0	24.92	222.5
Devils Tower	Northern Great Plains	2.11	0.00	101.0	0	126.0	0.72	200.0	0.80	83.0	1	1.0	18.57	190.0
Dinosaur	Northern Colorado Plateau	329.42	0.00	101.0	0	126.0	0.36	195.0	664.40	250.0	1	1.0	31.53	245.0
Dry Tortugas	South Florida Caribbean	102.47	0.00	101.0	0	126.0	0.00	96.5	0.00	40.0	No Data		0.05	7.0

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Ebey's Landing	North Coast and Cascades	27.90	0.00	101.0	0	126.0	0.00	96.5	0.00	40.0	1	1.0	5.78	102.0
Effigy Mounds	Heartland	3.88	23.19	246.0	0	126.0	0.00	96.5	2.63	115.0	1	1.0	17.13	182.0
Eisenhower	Mid Atlantic	1.09	0.20	208.0	0	126.0	0.00	96.5	2.71	117.0	1	1.0	3.92	73.0
El Malpais	Southern Colorado Plateau	182.63	0.00	101.0	0	126.0	0.00	96.5	7.98	150.0	1	1.0	3.55	67.0
El Morro	Southern Colorado Plateau	2.00	0.00	101.0	0	126.0	0.00	96.5	0.00	40.0	1	1.0	7.21	117.0
Everglades	South Florida Caribbean	2404.11	0.00	101.0	0	126.0	0.00	96.5	1331.68	259.0	1	1.0	0.01	4.0
Fire Island	Northeast Coastal and Barrier	30.72	0.06	204.0	0	126.0	0.00	96.5	0.00	40.0	1	1.0	0.53	24.0
Florissant Fossil Beds	Rocky Mountain	9.36	0.00	101.0	0	126.0	30.50	232.0	30.34	183.0	1	1.0	12.07	159.0
Fort Bowie	Sonoran Desert	1.56	0.00	101.0	0	126.0	0.00	96.5	4.23	128.0	1	1.0	17.77	187.0
Fort Caroline	Southeast Coast	0.22	0.00	101.0	0	126.0	0.00	96.5	0.00	40.0	1	1.0	1.99	40.0
Fort Davis	Chihuahuan Desert	0.81	0.00	101.0	0	126.0	0.00	96.5	0.00	40.0	1	1.0	17.35	183.0
Fort Donelson	Cumberland Piedmont	0.86	47.61	262.0	0	126.0	0.00	96.5	0.93	84.0	1	1.0	8.20	127.0
Fort Frederica	Southeast Coast	0.44	0.00	101.0	0	126.0	0.00	96.5	0.10	64.0	1	1.0	0.47	21.0
Fort Laramie	Northern Great Plains	1.33	0.00	101.0	0	126.0	4.99	215.0	1.05	88.0	1	1.0	2.68	46.0
Fort Larned	Southern Plains	1.10	0.00	101.0	0	126.0	0.00	96.5	1.64	99.0	1	1.0	0.50	22.0
Fort Matanzas	Southeast Coast	0.47	0.00	101.0	0	126.0	0.00	96.5	0.00	40.0	1	1.0	0.61	27.0
Fort Necessity	Eastern Rivers and Mountains	1.44	28.54	249.0	0	126.0	0.00	96.5	2.60	114.0	5	271.0	11.44	151.0

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Fort Point	San Francisco Bay Area	0.04	0.00	101.0	0	126.0	0.00	96.5	0.00	40.0	1	1.0	24.76	220.5
Fort Pulaski	Southeast Coast	8.66	0.00	101.0	0	126.0	0.00	96.5	11.95	159.0	1	1.0	0.16	10.0
Fort Sumter	Southeast Coast	0.36	0.00	101.0	0	126.0	0.00	96.5	0.00	40.0	1	1.0	0.46	20.0
Fort Union	Southern Plains	1.13	0.00	101.0	0	126.0	0.00	96.5	0.00	40.0	1	1.0	4.17	80.0
Fort Union Trading Post	Northern Great Plains	0.72	0.00	101.0	0	126.0	0.00	96.5	0.14	65.0	1	1.0	4.68	89.0
Fort Vancouver	North Coast and Cascades	0.34	0.00	101.0	0	126.0	0.00	96.5	0.00	40.0	1	1.0	3.81	70.0
Fossil Butte	Northern Colorado Plateau	13.00	0.00	101.0	0	126.0	0.00	96.5	9.13	153.0	1	1.0	21.68	207.0
Fredericksburg and Spotsylvania	Mid Atlantic	16.22	0.00	101.0	0	126.0	0.00	96.5	27.18	181.0	1	1.0	4.05	77.0
Friendship Hill	Eastern Rivers and Mountains	1.03	49.77	263.0	0	126.0	0.00	96.5	0.00	40.0	1	1.0	11.51	152.0
Gates of the Arctic	Arctic	13237.86	0.00	101.0	0	126.0	22003.12	271.0	No Data		No Data		14.30	170.0
Gateway	Northeast Coastal and Barrier	42.16	0.91	213.0	0	126.0	0.00	96.5	3.73	127.0	1	1.0	0.81	29.0
Gauley River	Eastern Rivers and Mountains	17.43	35.20	255.0	0	126.0	0.00	96.5	25.12	177.0	5	271.0	29.75	240.0
George Washington	National Capital Region	10.49	15.31	238.0	0	126.0	0.00	96.5	12.77	161.0	1	1.0	7.75	123.0
George Washington Birthplace	Northeast Coastal and Barrier	0.70	0.67	211.0	0	126.0	0.00	96.5	0.00	40.0	1	1.0	0.87	30.0
George Washington Carver	Heartland	0.33	0.00	101.0	0	126.0	0.00	96.5	0.39	76.0	1	1.0	2.27	42.0

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Gettysburg	Mid Atlantic	9.32	1.49	215.0	0	126.0	0.00	96.5	16.58	166.0	1	1.0	4.03	76.0
Gila Cliff Dwellings	Sonoran Desert	0.95	0.00	101.0	0	126.0	1.09	203.0	0.00	40.0	1	1.0	20.47	203.0
Glacier	Rocky Mountain	1575.11	0.00	101.0	9	261.0	16.94	227.0	2775.42	266.0	5	271.0	41.75	263.0
Glacier Bay	Southeast Alaska	5130.87	0.00	101.0	0	126.0	0.61	196.0	No Data		No Data		15.34	176.0
Glen Canyon	Southern Colorado Plateau	1954.63	0.00	101.0	0	126.0	0.00	96.5	1920.97	260.0	1	1.0	21.56	206.0
Golden Gate	San Francisco Bay Area	122.52	0.00	101.0	0	126.0	0.04	191.0	178.15	225.0	1	1.0	24.76	220.5
Golden Spike	Northern Colorado Plateau	4.17	0.00	101.0	0	126.0	0.00	96.5	3.51	125.0	1	1.0	15.57	177.0
Grand Canyon	Southern Colorado Plateau	1886.97	0.00	101.0	1	255.0	345.21	261.0	3463.83	268.0	1	1.0	39.22	260.0
Grand Portage	Great Lakes	1.11	0.29	209.0	0	126.0	0.00	96.5	2.10	104.0	5	271.0	8.34	131.0
Grand Teton	Greater Yellowstone	484.40	0.00	101.0	33	264.0	72.75	242.0	551.64	247.0	1	1.0	24.05	217.0
Grant-Kohrs Ranch	Rocky Mountain	2.47	0.00	101.0	0	126.0	0.00	96.5	2.12	107.0	1	1.0	4.13	78.0
Great Basin	Mojave Desert	120.31	0.00	101.0	0	126.0	125.56	249.0	128.69	218.0	1	1.0	43.20	265.0
Great Sand Dunes	Rocky Mountain	191.54	0.00	101.0	5	260.0	128.77	250.0	158.34	223.0	1	1.0	19.92	199.0
Great Smoky Mountains	Appalachian Highlands	810.14	60.40	269.0	0	126.0	943.76	265.0	1927.10	261.0	5	271.0	35.44	255.0
Guadalupe Mountains	Chihuahuan Desert	137.32	0.00	101.0	0	126.0	88.31	245.0	90.96	207.0	1	1.0	25.05	225.0
Guilford Courthouse	Cumberland Piedmont	0.34	0.00	101.0	0	126.0	0.00	96.5	0.45	77.0	1	1.0	3.75	69.0
Gulf Islands	Gulf Coast	188.25	0.00	101.0	0	126.0	0.00	96.5	2.11	105.0	1	1.0	0.51	23.0

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Hagerman Fossil Beds	Upper Columbia Basin	6.74	0.00	101.0	0	126.0	0.00	96.5	5.11	136.0	1	1.0	20.16	201.0
Haleakala	Pacific Island	45.72	0.00	101.0	0	126.0	3.17	212.0	39.17	188.0	No Data		15.68	179.0
Harpers Ferry	National Capital Region	5.80	16.99	242.0	0	126.0	0.00	96.5	2.76	119.0	5	271.0	26.64	232.0
Hawaii Volcanoes	Pacific Island	558.42	0.00	101.0	0	126.0	10.16	222.0	76.13	203.0	No Data		5.23	95.0
Herbert Hoover	Heartland	0.29	0.00	101.0	0	126.0	0.00	96.5	0.93	85.0	1	1.0	4.25	82.0
Home of Franklin D. Roosevelt	Northeast Temperate	1.40	44.71	260.0	0	126.0	0.00	96.5	1.57	97.0	1	1.0	6.01	106.0
Homestead	Heartland	0.35	0.00	101.0	0	126.0	1.07	202.0	0.00	40.0	1	1.0	2.88	53.0
Hopewell Culture	Heartland	1.75	5.52	226.0	0	126.0	0.00	96.5	0.60	80.0	1	1.0	2.61	45.0
Hopewell Furnace	Mid Atlantic	1.33	7.09	230.0	0	126.0	0.00	96.5	3.08	123.0	1	1.0	13.06	164.0
Horseshoe Bend	Southeast Coast	3.20	0.00	101.0	0	126.0	1.00	201.0	2.36	110.0	1	1.0	5.82	103.5
Hot Springs	Heartland	8.53	0.00	101.0	0	126.0	0.00	96.5	11.14	156.0	1	1.0	21.06	205.0
Hovenweep	Northern Colorado Plateau	1.26	0.00	101.0	0	126.0	0.00	96.5	2.11	106.0	1	1.0	7.54	120.0
Hubbell Trading Post	Southern Colorado Plateau	0.25	0.00	101.0	0	126.0	0.00	96.5	0.00	40.0	1	1.0	3.99	75.0
Indiana Dunes	Great Lakes	24.78	7.74	231.0	0	126.0	0.00	96.5	21.10	171.0	1	1.0	2.38	44.0
Isle Royale	Great Lakes	858.95	3.81	221.0	0	126.0	0.00	96.5	0.00	40.0	5	271.0	2.33	43.0
Jean Lafitte	Gulf Coast	29.11	0.00	101.0	0	126.0	0.00	96.5	10.94	155.0	1	1.0	0.04	6.0
Jewel Cave	Northern Great Plains	1.95	0.00	101.0	0	126.0	6.63	217.0	6.62	143.0	1	1.0	17.70	185.0
John Day Fossil Beds	Upper Columbia Basin	21.83	0.00	101.0	0	126.0	0.00	96.5	34.02	185.0	1	1.0	26.07	229.0

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John Muir	San Francisco Bay Area	0.54	0.00	101.0	0	126.0	0.00	96.5	0.18	67.0	1	1.0	24.43	218.0
Johnstown Flood	Eastern Rivers and Mountains	0.27	17.43	243.0	0	126.0	0.00	96.5	1.07	89.0	5	271.0	13.07	165.0
Joshua Tree	Mojave Desert	1238.97	0.00	101.0	0	126.0	0.00	96.5	1996.55	263.0	1	1.0	19.61	196.0
Kalaupapa	Pacific Island	16.63	0.00	101.0	0	126.0	0.00	96.5	26.50	180.0	No Data		6.10	108.0
Kaloko-Honokohau	Pacific Island	1.99	0.00	101.0	0	126.0	0.00	96.5	0.30	74.0	No Data		0.62	28.0
Katmai	Southwest Alaska	6405.79	0.00	101.0	0	126.0	226.70	258.0	No Data		No Data		9.32	141.0
Kenai Fjords	Southwest Alaska	1042.70	0.00	101.0	0	126.0	5.83	216.0	No Data		No Data		13.97	169.0
Kennesaw Mountain	Southeast Coast	4.53	0.00	101.0	0	126.0	6.72	218.0	6.69	144.0	1	1.0	10.46	148.0
Kings Canyon	Sierra Nevada	717.11	0.00	101.0	444	271.0	1048.10	266.0	1157.78	258.0	5	271.0	45.91	267.0
Kings Mountain	Cumberland Piedmont	6.19	0.00	101.0	0	126.0	0.00	96.5	4.81	134.0	1	1.0	7.55	121.0
Klondike Gold Rush	Southeast Alaska	20.30	0.00	101.0	0	126.0	0.70	199.0	No Data		No Data		17.96	189.0
Knife River Indian Villages	Northern Great Plains	2.79	0.00	101.0	0	126.0	0.00	96.5	1.62	98.0	1	1.0	3.86	71.0
Kobuk Valley	Arctic	2737.18	0.00	101.0	0	126.0	145.56	252.0	No Data		No Data		8.32	129.0
Lake Clark	Southwest Alaska	6303.97	0.00	101.0	0	126.0	2225.89	268.0	No Data		No Data		15.61	178.0
Lake Mead	Mojave Desert	2332.47	0.00	101.0	0	126.0	19.04	228.0	3993.74	270.0	1	1.0	19.66	197.0
Lake Meredith	Southern Plains	65.04	0.00	101.0	0	126.0	0.00	96.5	98.62	211.0	1	1.0	7.73	122.0

Park Name	Network Name	Park Area (square miles)	Percent Sensitive Vegetation Types	Ranking for Percent Sensitive Vegetation Types	Number of High Elevation Lakes	Ranking for Number of High Elevation Lakes	Kilometers of High Elevation Streams	Ranking for Kilometers of High Elevation Streams	Stream Order 1 - 3	Ranking for Stream Order 1 - 3	Sensitive Areas	Ranking for Sensitive Areas	Slope (degrees)	Ranking of Slope (degrees)
Lake Roosevelt	Upper Columbia Basin	163.61	0.00	101.0	0	126.0	0.00	96.5	123.19	215.0	1	1.0	9.58	142.0
Lassen Volcanic	Klamath	167.66	0.00	101.0	37	265.0	123.69	248.0	126.11	217.0	5	271.0	25.59	227.0
Lava Beds	Klamath	72.94	0.00	101.0	0	126.0	0.00	96.5	0.00	40.0	1	1.0	6.63	111.0
Lewis and Clark	North Coast and Cascades	5.58	0.00	101.0	0	126.0	0.00	96.5	5.43	137.0	1	1.0	10.72	150.0
Lincoln Boyhood	Heartland	0.31	35.15	254.0	0	126.0	0.00	96.5	0.00	40.0	1	1.0	3.51	66.0
Little Bighorn Battlefield	Rocky Mountain	1.22	0.00	101.0	0	126.0	0.00	96.5	0.00	40.0	1	1.0	8.95	137.0
Little River Canyon	Cumberland Piedmont	21.37	3.66	220.0	0	126.0	49.22	237.0	45.01	189.0	5	271.0	13.24	166.0
Lyndon B. Johnson	Southern Plains	2.62	0.00	101.0	0	126.0	0.00	96.5	2.40	112.0	1	1.0	3.16	57.0
Mammoth Cave	Cumberland Piedmont	80.77	29.84	251.0	0	126.0	0.00	96.5	59.38	198.0	1	1.0	12.25	161.0
Manassas	National Capital Region	8.01	0.18	207.0	0	126.0	0.00	96.5	15.11	164.0	1	1.0	3.49	63.0
Manzanar	Mojave Desert	1.27	0.00	101.0	0	126.0	0.00	96.5	2.14	108.0	1	1.0	4.48	86.0
Marsh-Billings-Rockefeller	Northeast Temperate	1.00	47.46	261.0	0	126.0	0.00	96.5	0.26	72.0	5	271.0	17.37	184.0
Mesa Verde	Southern Colorado Plateau	83.88	0.00	101.0	0	126.0	40.55	235.0	170.63	224.0	1	1.0	27.60	235.0
Minute Man	Northeast Temperate	1.49	2.89	218.0	0	126.0	0.00	96.5	1.08	91.0	5	271.0	4.30	83.0
Mississippi	Great Lakes	84.11	7.78	233.0	0	126.0	0.00	96.5	51.26	193.0	1	1.0	5.20	93.0
Missouri	Northern Great Plains	107.87	1.03	214.0	0	126.0	0.00	96.5	58.12	195.0	1	1.0	2.71	48.0
Mojave	Mojave Desert	2483.03	0.00	101.0	0	126.0	3.08	211.0	3147.51	267.0	1	1.0	11.75	154.0

Park Name	Network Name	Park Area (square miles)	Percent Sensitive Vegetation Types	Ranking for Percent Sensitive Vegetation Types	Number of High Elevation Lakes	Ranking for Number of High Elevation Lakes	Kilometers of High Elevation Streams	Ranking for Kilometers of High Elevation Streams	Stream Order 1 - 3	Ranking for Stream Order 1 - 3	Sensitive Areas	Ranking for Sensitive Areas	Slope (degrees)	Ranking of Slope (degrees)
Monocacy	National Capital Region	2.53	5.51	225.0	0	126.0	0.00	96.5	5.96	139.0	1	1.0	6.66	112.0
Montezuma Castle	Sonoran Desert	1.33	0.00	101.0	0	126.0	0.00	96.5	0.17	66.0	1	1.0	11.76	155.0
Moores Creek	Southeast Coast	0.16	0.00	101.0	0	126.0	0.00	96.5	0.52	78.0	1	1.0	1.31	35.0
Morristown	Northeast Temperate	2.67	59.86	268.0	0	126.0	0.00	96.5	3.22	124.0	5	271.0	12.16	160.0
Mount Rainier	North Coast and Cascades	367.56	0.00	101.0	44	266.0	272.44	259.0	666.36	251.0	5	271.0	46.52	268.0
Mount Rushmore	Northern Great Plains	2.02	0.00	101.0	0	126.0	0.00	96.5	0.05	63.0	1	1.0	24.56	219.0
Muir Woods	San Francisco Bay Area	0.90	0.00	101.0	0	126.0	0.00	96.5	3.53	126.0	1	1.0	28.30	238.0
Natchez Trace Parkway and National Scenic Trail	Gulf Coast	71.52	3.96	222.0	0	126.0	59.92	241.0	185.84	227.0	1	1.0	3.93	74.0
National Capital Parks - East	National Capital Region	5.94	4.11	223.0	0	126.0	1.10	204.0	7.87	149.0	1	1.0	5.02	91.0
National Park of American Samoa	Pacific Island	16.66	0.00	101.0	0	126.0	No Data		No Data		No Data		No Data	
Natural Bridges	Northern Colorado Plateau	11.56	0.00	101.0	0	126.0	0.00	96.5	23.24	174.0	1	1.0	16.48	181.0
Navajo	Southern Colorado Plateau	0.56	0.00	101.0	0	126.0	0.00	96.5	0.65	82.0	1	1.0	35.23	253.0
New River Gorge	Eastern Rivers and Mountains	109.98	6.02	228.0	0	126.0	55.46	240.0	143.73	222.0	5	271.0	35.21	252.0
Nez Perce	Upper Columbia Basin	5.39	0.00	101.0	0	126.0	0.00	96.5	13.26	163.0	1	1.0	24.92	222.5

Park Name	Network Name	Park Area (square miles)	Percent Sensitive Vegetation Types	Ranking for Percent Sensitive Vegetation Types	Number of High Elevation Lakes	Ranking for Number of High Elevation Lakes	Kilometers of High Elevation Streams	Ranking for Kilometers of High Elevation Streams	Stream Order 1 - 3	Ranking for Stream Order 1 - 3	Sensitive Areas	Ranking for Sensitive Areas	Slope (degrees)	Ranking of Slope (degrees)
Ninety Six	Cumberland Piedmont	1.50	0.00	101.0	0	126.0	0.00	96.5	4.79	132.0	1	1.0	3.51	65.0
Niobrara	Northern Great Plains	45.47	0.00	101.0	0	126.0	0.00	96.5	58.42	197.0	1	1.0	8.85	135.0
Noatak	Arctic	10280.90	0.00	101.0	0	126.0	3546.99	269.0	No Data		No Data		6.84	114.0
North Cascades	North Coast and Cascades	782.91	0.00	101.0	53	267.0	310.41	260.0	1073.98	256.0	5	271.0	56.24	270.0
Obed	Appalachian Highlands	8.32	19.57	244.0	0	126.0	0.00	96.5	9.19	154.0	5	271.0	19.32	195.0
Ocmulgee	Southeast Coast	1.08	0.00	101.0	0	126.0	0.00	96.5	0.00	40.0	1	1.0	3.67	68.0
Olympic	North Coast and Cascades	1428.42	0.00	101.0	29	263.0	145.56	253.0	2004.88	264.0	1	1.0	46.60	269.0
Oregon Caves	Klamath	0.73	0.00	101.0	0	126.0	0.00	96.5	0.00	40.0	1	1.0	44.59	266.0
Organ Pipe Cactus	Sonoran Desert	516.70	0.00	101.0	0	126.0	0.00	96.5	1011.59	254.0	1	1.0	8.96	138.0
Ozark	Heartland	128.62	0.00	101.0	0	126.0	0.00	96.5	276.33	240.0	1	1.0	14.46	171.0
Padre Island	Gulf Coast	204.94	0.00	101.0	0	126.0	0.00	96.5	0.00	40.0	1	1.0	0.21	14.0
Palo Alto Battlefield	Gulf Coast	5.33	0.00	101.0	0	126.0	0.00	96.5	0.00	40.0	1	1.0	0.20	13.0
Pea Ridge	Heartland	6.67	0.00	101.0	0	126.0	8.18	220.0	8.08	151.0	1	1.0	7.41	119.0
Pecos	Southern Plains	10.20	0.00	101.0	0	126.0	29.65	231.0	24.98	176.0	1	1.0	10.53	149.0
Petersburg	Mid Atlantic	5.24	0.01	202.0	0	126.0	0.00	96.5	7.33	146.0	1	1.0	2.94	54.0
Petrified Forest	Southern Colorado Plateau	348.43	0.00	101.0	0	126.0	0.00	96.5	751.48	252.0	1	1.0	4.46	85.0
Petroglyph	Southern Colorado Plateau	11.25	0.00	101.0	0	126.0	0.00	96.5	2.76	120.0	1	1.0	8.79	134.0
Pictured Rocks	Great Lakes	115.12	52.83	265.0	0	126.0	0.00	96.5	96.86	209.0	5	271.0	5.75	101.0

Park Name	Network Name	Park Area (square miles)	Percent Sensitive Vegetation Types	Ranking for Percent Sensitive Vegetation Types	Number of High Elevation Lakes	Ranking for Number of High Elevation Lakes	Kilometers of High Elevation Streams	Ranking for Kilometers of High Elevation Streams	Stream Order 1 - 3	Ranking for Stream Order 1 - 3	Sensitive Areas	Ranking for Sensitive Areas	Slope (degrees)	Ranking of Slope (degrees)
Pinnacles	San Francisco Bay Area	42.42	0.00	101.0	0	126.0	15.41	226.0	96.59	208.0	1	1.0	28.56	239.0
Pipe Spring	Northern Colorado Plateau	0.06	0.00	101.0	0	126.0	0.00	96.5	0.00	40.0	1	1.0	9.30	140.0
Pipestone	Heartland	0.44	0.00	101.0	0	126.0	2.09	209.0	2.06	102.0	1	1.0	4.51	87.0
Point Reyes	San Francisco Bay Area	112.29	0.00	101.0	0	126.0	0.00	96.5	142.28	220.0	1	1.0	18.80	192.0
Prince William Forest	National Capital Region	17.33	13.66	235.0	0	126.0	0.00	96.5	36.04	186.0	1	1.0	5.40	99.0
Pu'uhonua o Honaunau	Pacific Island	0.66	0.00	101.0	0	126.0	0.00	96.5	0.23	69.0	No Data		5.22	94.0
Puukohola Heiau	Pacific Island	0.13	0.00	101.0	0	126.0	0.00	96.5	0.22	68.0	No Data		4.15	79.0
Rainbow Bridge	Southern Colorado Plateau	0.25	0.00	101.0	0	126.0	0.00	96.5	1.07	90.0	1	1.0	39.48	261.0
Redwood	Klamath	180.69	0.00	101.0	0	126.0	0.00	96.5	220.67	234.0	1	1.0	29.94	242.0
Richmond	Mid Atlantic	2.37	0.00	101.0	0	126.0	0.00	96.5	5.97	140.0	1	1.0	3.33	59.0
Rock Creek Park	National Capital Region	4.23	16.74	241.0	0	126.0	0.00	96.5	12.97	162.0	1	1.0	7.92	125.0
Rocky Mountain	Rocky Mountain	417.06	0.00	101.0	101	268.0	589.69	263.0	579.81	248.0	5	271.0	39.94	262.0
Russell Cave	Cumberland Piedmont	0.50	5.65	227.0	0	126.0	0.00	96.5	0.54	79.0	1	1.0	32.00	247.0
Sagamore Hill	Northeast Coastal and Barrier	0.11	2.09	217.0	0	126.0	0.00	96.5	0.00	40.0	1	1.0	8.57	133.0
Saguaro	Sonoran Desert	146.02	0.00	101.0	0	126.0	52.90	238.0	230.61	236.0	1	1.0	27.93	236.0
Saint Croix	Great Lakes	152.70	26.86	247.0	1	255.0	8.22	221.0	196.21	228.0	5	271.0	6.23	109.0
Saint-Gaudens	Northeast Temperate	0.23	26.93	248.0	0	126.0	0.00	96.5	1.66	100.0	5	271.0	17.75	186.0

Park Name	Network Name	Park Area (square miles)	Percent Sensitive Vegetation Types	Ranking for Percent Sensitive Vegetation Types	Number of High Elevation Lakes	Ranking for Number of High Elevation Lakes	Kilometers of High Elevation Streams	Ranking for Kilometers of High Elevation Streams	Stream Order 1 - 3	Ranking for Stream Order 1 - 3	Sensitive Areas	Ranking for Sensitive Areas	Slope (degrees)	Ranking of Slope (degrees)
Salinas Pueblo Missions	Southern Colorado Plateau	1.66	0.00	101.0	0	126.0	0.00	96.5	3.08	122.0	1	1.0	7.22	118.0
San Antonio Missions	Gulf Coast	1.29	0.00	101.0	0	126.0	1.69	208.0	2.08	103.0	1	1.0	3.23	58.0
San Juan Island	North Coast and Cascades	2.69	0.00	101.0	0	126.0	0.00	96.5	0.00	40.0	1	1.0	12.01	158.0
Santa Monica Mountains	Mediterranean Coast	234.38	0.00	101.0	0	126.0	0.00	96.5	435.39	245.0	1	1.0	28.21	237.0
Saratoga	Northeast Temperate	4.49	16.66	240.0	0	126.0	0.00	96.5	2.72	118.0	1	1.0	5.26	96.0
Saugus Iron Works	Northeast Temperate	0.02	0.00	101.0	0	126.0	0.00	96.5	0.24	70.0	5	271.0	4.64	88.0
Scotts Bluff	Northern Great Plains	5.06	0.00	101.0	0	126.0	0.00	96.5	0.00	40.0	1	1.0	13.92	168.0
Sequoia	Sierra Nevada	635.63	0.00	101.0	205	269.0	695.77	264.0	1045.60	255.0	5	271.0	42.72	264.0
Shenandoah	Mid Atlantic	301.99	29.30	250.0	0	126.0	199.07	256.0	246.97	238.0	5	271.0	34.32	249.0
Shiloh	Cumberland Piedmont	6.38	0.00	101.0	0	126.0	0.00	96.5	12.18	160.0	1	1.0	3.41	61.0
Sitka	Southeast Alaska	0.18	0.00	101.0	0	126.0	0.00	96.5	No Data		No Data		0.95	32.0
Sleeping Bear Dunes	Great Lakes	109.72	52.23	264.0	0	126.0	0.00	96.5	21.34	172.0	1	1.0	7.79	124.0
Stones River	Cumberland Piedmont	1.11	0.06	205.0	0	126.0	0.00	96.5	0.00	40.0	1	1.0	1.63	37.0
Sunset Crater Volcano	Southern Colorado Plateau	4.75	0.00	101.0	0	126.0	0.00	96.5	0.00	40.0	1	1.0	18.86	193.0
Tallgrass Prairie	Heartland	17.09	0.04	203.0	0	126.0	28.16	230.0	47.44	190.0	1	1.0	5.84	105.0
Theodore Roosevelt	Northern Great Plains	109.97	0.00	101.0	0	126.0	0.00	96.5	239.72	237.0	1	1.0	11.59	153.0

Park Name	Network Name	Park Area (square miles)	Percent Sensitive Vegetation Types	Ranking for Percent Sensitive Vegetation Types	Number of High Elevation Lakes	Ranking for Number of High Elevation Lakes	Kilometers of High Elevation Streams	Ranking for Kilometers of High Elevation Streams	Stream Order 1 - 3	Ranking for Stream Order 1 - 3	Sensitive Areas	Ranking for Sensitive Areas	Slope (degrees)	Ranking of Slope (degrees)
Thomas Stone	Northeast Coastal and Barrier	0.51	0.53	210.0	0	126.0	0.00	96.5	0.00	40.0	1	1.0	3.87	72.0
Timpanogos Cave	Northern Colorado Plateau	0.39	0.00	101.0	0	126.0	0.00	96.5	1.16	93.0	1	1.0	59.20	271.0
Timucaun Ecological and Historical Preserve	Southeast Coast	71.40	0.00	101.0	0	126.0	0.00	96.5	209.72	231.0	1	1.0	0.32	18.0
Tonto	Sonoran Desert	1.75	0.00	101.0	0	126.0	0.00	96.5	4.42	130.0	1	1.0	27.23	233.0
Tumacacori	Sonoran Desert	0.57	0.00	101.0	0	126.0	0.00	96.5	0.37	75.0	1	1.0	2.68	47.0
Tuzigoot	Sonoran Desert	1.27	0.00	101.0	0	126.0	0.00	96.5	2.65	116.0	1	1.0	9.23	139.0
Upper Delaware	Eastern Rivers and Mountains	86.17	31.44	252.0	0	126.0	0.00	96.5	70.41	200.0	5	271.0	24.03	216.0
Valley Forge	Mid Atlantic	5.39	1.92	216.0	0	126.0	0.00	96.5	4.31	129.0	1	1.0	8.33	130.0
Vanderbilt Mansion	Northeast Temperate	0.33	39.63	258.0	0	126.0	0.00	96.5	1.04	87.0	1	1.0	13.39	167.0
Vicksburg	Gulf Coast	2.58	0.00	101.0	0	126.0	0.00	96.5	5.56	138.0	1	1.0	5.66	100.0
Virgin Islands	South Florida Caribbean	23.07	0.00	101.0	0	126.0	0.00	96.5	17.14	167.0	No Data		7.08	115.0
Voyageurs	Great Lakes	320.18	0.10	206.0	0	126.0	0.00	96.5	369.23	243.0	5	271.0	3.47	62.0
Walnut Canyon	Southern Colorado Plateau	5.58	0.00	101.0	0	126.0	0.00	96.5	20.38	170.0	1	1.0	15.30	175.0
War in the Pacific	Pacific Island	2.98	0.00	101.0	0	126.0	No Data		No Data		No Data		No Data	
Washita Battlefield	Southern Plains	0.49	0.00	101.0	0	126.0	0.00	96.5	0.01	61.0	1	1.0	2.78	49.5
Weir Farm	Northeast Temperate	0.09	6.82	229.0	0	126.0	0.00	96.5	0.29	73.0	5	271.0	4.22	81.0
Whiskeytown	Klamath	65.84	0.00	101.0	0	126.0	0.21	192.0	90.21	206.0	1	1.0	33.20	248.0

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White Sands	Chihuahuan Desert	227.32	0.00	101.0	0	126.0	0.00	96.5	74.01	202.0	1	1.0	0.94	31.0
Whitman Mission	Upper Columbia Basin	0.16	0.00	101.0	0	126.0	0.00	96.5	1.14	92.0	1	1.0	3.50	64.0
Wilson's Creek	Heartland	3.73	0.00	101.0	0	126.0	0.00	96.5	11.56	157.0	1	1.0	6.76	113.0
Wind Cave	Northern Great Plains	44.26	0.00	101.0	1	255.0	86.32	244.0	114.91	213.0	1	1.0	11.85	157.0
Wolf Trap National Park for the Performing Arts	National Capital Region	0.21	8.78	234.0	0	126.0	0.00	96.5	1.90	101.0	1	1.0	4.35	84.0
Wrangell-St. Elias	Central Alaska	20588.98	0.00	101.0	0	126.0	6205.77	270.0	No Data		No Data		12.76	162.0
Wupatki	Southern Colorado Plateau	55.39	0.00	101.0	0	126.0	0.00	96.5	121.65	214.0	1	1.0	6.07	107.0
Yellowstone	Greater Yellowstone	3436.65	0.00	101.0	19	262.0	162.68	255.0	3643.76	269.0	5	271.0	19.98	200.0
Yosemite	Sierra Nevada	1164.65	0.00	101.0	229	270.0	1297.87	267.0	1987.71	262.0	5	271.0	34.99	250.0
Yucca House	Southern Colorado Plateau	0.06	0.00	101.0	0	126.0	0.00	96.5	0.00	40.0	1	1.0	9.87	146.0
Yukon-Charley Rivers	Central Alaska	3940.33	0.00	101.0	0	126.0	135.11	251.0	No Data		No Data		9.72	143.0
Zion	Northern Colorado Plateau	232.40	0.00	101.0	0	126.0	0.00	96.5	403.13	244.0	1	1.0	37.77	258.0

Table A-3. Park Protection Variables

Park Name	Network Name	Park Area (square miles)	Percent of Park Receiving Special Protection	Park Ranking for Percent of Park Receiving Special Protection	Area of Park Receiving Special Protection	Ranking for Area of Park Receiving Special Protection
Abraham Lincoln Birthplace	Cumberland Piedmont	0.53	0.00	97.0	0.00	97.0
Acadia	Northeast Temperate	60.61	97.15	236.0	58.88	223.0
Agate Fossil Beds	Northern Great Plains	4.76	0.00	97.0	0.00	97.0
Alagnak	Southwest Alaska	48.29	3.79	205.0	1.83	207.0
Alibates Flint Quarries	Southern Plains	2.14	0.00	97.0	0.00	97.0
Allegheny Portage Railroad	Eastern Rivers and Mountains	1.67	0.00	97.0	0.00	97.0
American Memorial Park	Pacific Island	0.21	0.00	97.0	0.00	97.0
Amistad	Chihuahuan Desert	89.95	0.00	97.0	0.00	97.0
Aniakchak	Southwest Alaska	942.86	0.00	97.0	0.00	97.0
Antietam	National Capital Region	5.08	0.00	97.0	0.00	97.0
Apostle Islands	Great Lakes	107.42	0.00	97.0	0.00	97.0
Appomattox Court House	Mid Atlantic	2.78	0.00	97.0	0.00	97.0
Arches	Northern Colorado Plateau	119.47	99.91	253.0	119.36	231.0
Arkansas Post	Heartland	0.66	0.00	97.0	0.00	97.0
Assateague Island	Northeast Coastal and Barrier	76.15	0.00	97.0	0.00	97.0
Aztec Ruins	Southern Colorado Plateau	0.49	0.00	97.0	0.00	97.0
Badlands	Northern Great Plains	379.27	25.79	213.0	97.81	228.0
Bandelier	Southern Colorado Plateau	52.80	77.52	224.0	40.93	216.0
Bent's Old Fort	Southern Plains	1.25	0.00	97.0	0.00	97.0
Bering Land Bridge	Arctic	4351.17	0.00	97.0	0.00	97.0
Big Bend	Chihuahuan Desert	1270.68	99.81	252.0	1268.29	258.0
Big Cypress	South Florida Caribbean	1139.86	0.02	195.0	0.24	202.0
Big Hole	Upper Columbia Basin	1.05	0.00	97.0	0.00	97.0

Park Name	Network Name	Park Area (square miles)	Percent of Park Receiving Special Protection	Park Ranking for Percent of Park Receiving Special Protection	Area of Park Receiving Special Protection	Ranking for Area of Park Receiving Special Protection
Big South Fork	Appalachian Highlands	191.41	0.00	97.0	0.00	97.0
Big Thicket	Gulf Coast	138.78	0.00	97.0	0.00	97.0
Bighorn Canyon	Greater Yellowstone	186.79	0.00	97.0	0.00	97.0
Biscayne	South Florida Caribbean	274.36	0.00	97.0	0.00	97.0
Black Canyon of the Gunnison	Northern Colorado Plateau	48.99	50.90	217.0	24.94	214.0
Blue Ridge	Appalachian Highlands	141.45	1.01	204.0	1.42	206.0
Bluestone	Eastern Rivers and Mountains	6.78	0.00	97.0	0.00	97.0
Booker T. Washington	Mid Atlantic	0.37	0.00	97.0	0.00	97.0
Boston Harbor Islands	Northeast Temperate	2.49	0.00	97.0	0.00	97.0
Bryce Canyon	Northern Colorado Plateau	56.23	99.68	248.0	56.05	221.0
Buck Island Reef	South Florida Caribbean	29.67	0.00	97.0	0.00	97.0
Buffalo	Heartland	146.16	38.50	214.0	56.28	222.0
Cabrillo	Mediterranean Coast	0.25	0.00	97.0	0.00	97.0
Canaveral	Southeast Coast	91.34	0.00	97.0	0.00	97.0
Canyon de Chelly	Southern Colorado Plateau	144.62	0.00	97.0	0.00	97.0
Canyonlands	Northern Colorado Plateau	523.32	99.65	246.0	521.48	248.0
Cape Cod	Northeast Coastal and Barrier	63.35	0.00	97.0	0.00	97.0
Cape Hatteras	Southeast Coast	48.58	0.00	97.0	0.00	97.0
Cape Krusenstern	Arctic	1031.23	0.00	97.0	0.00	97.0
Cape Lookout	Southeast Coast	43.66	0.00	97.0	0.00	97.0
Capitol Reef	Northern Colorado Plateau	381.42	99.32	240.0	378.81	244.0
Capulin Volcano	Southern Plains	1.24	0.00	97.0	0.00	97.0
Carl Sandburg Home	Cumberland Piedmont	0.42	0.00	97.0	0.00	97.0
Carlsbad Caverns	Chihuahuan Desert	73.12	100.00	271.0	73.12	224.0
Casa Grande Ruins	Sonoran Desert	0.73	0.00	97.0	0.00	97.0

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Castillo de San Marcos	Southeast Coast	0.03	0.00	97.0	0.00	97.0
Catoctin Mountain	National Capital Region	8.92	0.00	97.0	0.00	97.0
Cedar Breaks	Northern Colorado Plateau	9.59	0.09	199.0	0.01	197.0
Chaco Culture	Southern Colorado Plateau	53.64	0.00	97.0	0.00	97.0
Channel Islands	Mediterranean Coast	382.75	0.00	97.0	0.00	97.0
Chattahoochee River	Southeast Coast	13.59	0.00	97.0	0.00	97.0
Chesapeake and Ohio Canal	National Capital Region	32.95	0.00	97.0	0.00	97.0
Chickamauga and Chattanooga	Cumberland Piedmont	12.86	0.00	97.0	0.00	97.0
Chickasaw	Southern Plains	15.43	0.00	97.0	0.00	97.0
Chiricahua	Sonoran Desert	19.01	99.97	260.0	19.00	211.0
City of Rocks	Upper Columbia Basin	22.79	0.00	97.0	0.00	97.0
Colonial	Northeast Coastal and Barrier	14.70	0.00	97.0	0.00	97.0
Colorado	Northern Colorado Plateau	31.90	0.00	97.0	0.00	97.0
Congaree	Southeast Coast	37.89	65.12	222.0	24.67	213.0
Coronado	Sonoran Desert	7.60	0.04	198.0	0.00	194.0
Cowpens	Cumberland Piedmont	1.31	0.00	97.0	0.00	97.0
Crater Lake	Klamath	284.04	99.49	244.0	282.58	237.0
Craters of the Moon	Upper Columbia Basin	733.96	10.01	207.0	73.45	225.0
Cumberland Gap	Cumberland Piedmont	38.84	0.00	97.0	0.00	97.0
Cumberland Island	Southeast Coast	56.92	21.55	212.0	12.26	210.0
Curecanti	Northern Colorado Plateau	64.08	0.00	97.0	0.00	97.0
Cuyahoga Valley	Heartland	52.21	0.00	97.0	0.00	97.0
Death Valley	Mojave Desert	5314.15	80.69	227.0	4288.00	266.0
Delaware Water Gap	Eastern Rivers and Mountains	107.20	0.00	97.0	0.00	97.0
Denali	Central Alaska	9416.92	77.69	225.0	7316.11	268.0

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Devils Postpile	Sierra Nevada	1.25	100.00	265.0	1.25	205.0
Devils Tower	Northern Great Plains	2.11	0.00	97.0	0.00	97.0
Dinosaur	Northern Colorado Plateau	329.42	0.00	97.0	0.00	97.0
Dry Tortugas	South Florida Caribbean	102.47	0.00	97.0	0.00	97.0
Ebey's Landing	North Coast and Cascades	27.90	0.00	97.0	0.00	97.0
Effigy Mounds	Heartland	3.88	0.00	97.0	0.00	97.0
Eisenhower	Mid Atlantic	1.09	0.00	97.0	0.00	97.0
El Malpais	Southern Colorado Plateau	182.63	0.28	201.0	0.51	204.0
El Morro	Southern Colorado Plateau	2.00	0.00	97.0	0.00	97.0
Everglades	South Florida Caribbean	2404.11	99.96	259.0	2403.21	262.0
Fire Island	Northeast Coastal and Barrier	30.72	12.56	210.0	3.86	208.0
Florissant Fossil Beds	Rocky Mountain	9.36	0.00	97.0	0.00	97.0
Fort Bowie	Sonoran Desert	1.56	0.00	97.0	0.00	97.0
Fort Caroline	Southeast Coast	0.22	0.00	97.0	0.00	97.0
Fort Davis	Chihuahuan Desert	0.81	0.00	97.0	0.00	97.0
Fort Donelson	Cumberland Piedmont	0.86	0.00	97.0	0.00	97.0
Fort Frederica	Southeast Coast	0.44	0.00	97.0	0.00	97.0
Fort Laramie	Northern Great Plains	1.33	0.00	97.0	0.00	97.0
Fort Larned	Southern Plains	1.10	0.00	97.0	0.00	97.0
Fort Matanzas	Southeast Coast	0.47	0.00	97.0	0.00	97.0
Fort Necessity	Eastern Rivers and Mountains	1.44	0.00	97.0	0.00	97.0
Fort Point	San Francisco Bay Area	0.04	0.00	97.0	0.00	97.0
Fort Pulaski	Southeast Coast	8.66	0.00	97.0	0.00	97.0
Fort Sumter	Southeast Coast	0.36	0.00	97.0	0.00	97.0
Fort Union	Southern Plains	1.13	0.00	97.0	0.00	97.0

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Fort Union Trading Post	Northern Great Plains	0.72	0.00	97.0	0.00	97.0
Fort Vancouver	North Coast and Cascades	0.34	0.00	97.0	0.00	97.0
Fossil Butte	Northern Colorado Plateau	13.00	0.00	97.0	0.00	97.0
Fredericksburg and Spotsylvania	Mid Atlantic	16.22	0.00	97.0	0.00	97.0
Friendship Hill	Eastern Rivers and Mountains	1.03	0.00	97.0	0.00	97.0
Gates of the Arctic	Arctic	13237.86	85.53	231.0	11322.63	270.0
Gateway	Northeast Coastal and Barrier	42.16	0.00	97.0	0.00	97.0
Gauley River	Eastern Rivers and Mountains	17.43	0.00	97.0	0.00	97.0
George Washington	National Capital Region	10.49	0.00	97.0	0.00	97.0
George Washington Birthplace	Northeast Coastal and Barrier	0.70	0.00	97.0	0.00	97.0
George Washington Carver	Heartland	0.33	0.00	97.0	0.00	97.0
Gettysburg	Mid Atlantic	9.32	0.00	97.0	0.00	97.0
Gila Cliff Dwellings	Sonoran Desert	0.95	0.57	203.0	0.01	196.0
Glacier	Rocky Mountain	1575.11	99.95	257.0	1574.29	260.0
Glacier Bay	Southeast Alaska	5130.87	79.86	226.0	4097.51	265.0
Glen Canyon	Southern Colorado Plateau	1954.63	0.00	194.0	0.01	198.0
Golden Gate	San Francisco Bay Area	122.52	0.03	196.0	0.03	199.0
Golden Spike	Northern Colorado Plateau	4.17	0.00	97.0	0.00	97.0
Grand Canyon	Southern Colorado Plateau	1886.97	99.42	242.0	1876.00	261.0
Grand Portage	Great Lakes	1.11	0.00	97.0	0.00	97.0
Grand Teton	Greater Yellowstone	484.40	99.79	251.0	483.39	247.0
Grant-Kohrs Ranch	Rocky Mountain	2.47	0.00	97.0	0.00	97.0
Great Basin	Mojave Desert	120.31	0.00	97.0	0.00	97.0

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Great Sand Dunes	Rocky Mountain	191.54	60.73	218.0	116.33	230.0
Great Smoky Mountains	Appalachian Highlands	810.14	98.13	238.0	794.98	253.0
Guadalupe Mountains	Chihuahuan Desert	137.32	99.66	247.0	136.86	233.0
Guilford Courthouse	Cumberland Piedmont	0.34	0.00	97.0	0.00	97.0
Gulf Islands	Gulf Coast	188.25	6.09	206.0	11.46	209.0
Hagerman Fossil Beds	Upper Columbia Basin	6.74	0.00	97.0	0.00	97.0
Haleakala	Pacific Island	45.72	96.50	235.0	44.12	217.0
Harpers Ferry	National Capital Region	5.80	0.00	97.0	0.00	97.0
Hawaii Volcanoes	Pacific Island	558.42	99.97	262.0	558.27	249.0
Herbert Hoover	Heartland	0.29	0.00	97.0	0.00	97.0
Home of Franklin D. Roosevelt	Northeast Temperate	1.40	0.00	97.0	0.00	97.0
Homestead	Heartland	0.35	0.00	97.0	0.00	97.0
Hopewell Culture	Heartland	1.75	0.00	97.0	0.00	97.0
Hopewell Furnace	Mid Atlantic	1.33	0.00	97.0	0.00	97.0
Horseshoe Bend	Southeast Coast	3.20	0.00	97.0	0.00	97.0
Hot Springs	Heartland	8.53	0.00	97.0	0.00	97.0
Hovenweep	Northern Colorado Plateau	1.26	0.00	97.0	0.00	97.0
Hubbell Trading Post	Southern Colorado Plateau	0.25	0.00	97.0	0.00	97.0
Indiana Dunes	Great Lakes	24.78	0.00	97.0	0.00	97.0
Isle Royale	Great Lakes	858.95	99.97	261.0	858.69	254.0
Jean Lafitte	Gulf Coast	29.11	0.00	97.0	0.00	97.0
Jewel Cave	Northern Great Plains	1.95	0.00	97.0	0.00	97.0
John Day Fossil Beds	Upper Columbia Basin	21.83	0.00	97.0	0.00	97.0
John Muir	San Francisco Bay Area	0.54	0.00	97.0	0.00	97.0
Johnstown Flood	Eastern Rivers and Mountains	0.27	0.00	97.0	0.00	97.0
Joshua Tree	Mojave Desert	1238.97	86.03	232.0	1065.89	255.0

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Kalaupapa	Pacific Island	16.63	0.00	97.0	0.00	97.0
Kaloko-Honokohau	Pacific Island	1.99	0.00	97.0	0.00	97.0
Katmai	Southwest Alaska	6405.79	80.77	228.0	5174.17	267.0
Kenai Fjords	Southwest Alaska	1042.70	0.03	197.0	0.33	203.0
Kennesaw Mountain	Southeast Coast	4.53	0.00	97.0	0.00	97.0
Kings Canyon	Sierra Nevada	717.11	99.96	258.0	716.82	251.0
Kings Mountain	Cumberland Piedmont	6.19	0.00	97.0	0.00	97.0
Klondike Gold Rush	Southeast Alaska	20.30	0.00	97.0	0.00	97.0
Knife River Indian Villages	Northern Great Plains	2.79	0.00	97.0	0.00	97.0
Kobuk Valley	Arctic	2737.18	10.42	209.0	285.35	238.0
Lake Clark	Southwest Alaska	6303.97	64.81	221.0	4085.61	264.0
Lake Mead	Mojave Desert	2332.47	14.98	211.0	349.45	242.0
Lake Meredith	Southern Plains	65.04	0.00	97.0	0.00	97.0
Lake Roosevelt	Upper Columbia Basin	163.61	0.00	97.0	0.00	97.0
Lassen Volcanic	Klamath	167.66	99.49	245.0	166.81	234.0
Lava Beds	Klamath	72.94	63.96	220.0	46.65	219.0
Lewis and Clark	North Coast and Cascades	5.58	0.00	97.0	0.00	97.0
Lincoln Boyhood	Heartland	0.31	0.00	97.0	0.00	97.0
Little Bighorn Battlefield	Rocky Mountain	1.22	0.00	97.0	0.00	97.0
Little River Canyon	Cumberland Piedmont	21.37	0.00	97.0	0.00	97.0
Lyndon B. Johnson	Southern Plains	2.62	0.00	97.0	0.00	97.0
Mammoth Cave	Cumberland Piedmont	80.77	96.35	234.0	77.82	226.0
Manassas	National Capital Region	8.01	0.00	97.0	0.00	97.0
Manzanar	Mojave Desert	1.27	0.00	97.0	0.00	97.0
Marsh-Billings-Rockefeller	Northeast Temperate	1.00	0.00	97.0	0.00	97.0
Mesa Verde	Southern Colorado Plateau	83.88	99.32	241.0	83.31	227.0

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Minute Man	Northeast Temperate	1.49	0.00	97.0	0.00	97.0
Mississippi	Great Lakes	84.11	0.00	97.0	0.00	97.0
Missouri	Northern Great Plains	107.87	0.00	97.0	0.00	97.0
Mojave	Mojave Desert	2483.03	45.74	215.0	1135.77	256.0
Monocacy	National Capital Region	2.53	0.00	97.0	0.00	97.0
Montezuma Castle	Sonoran Desert	1.33	0.00	97.0	0.00	97.0
Moores Creek	Southeast Coast	0.16	0.00	97.0	0.00	97.0
Morristown	Northeast Temperate	2.67	0.00	97.0	0.00	97.0
Mount Rainier	North Coast and Cascades	367.56	99.94	255.0	367.35	243.0
Mount Rushmore	Northern Great Plains	2.02	0.21	200.0	0.00	195.0
Muir Woods	San Francisco Bay Area	0.90	0.00	97.0	0.00	97.0
Natchez Trace Parkway and National Scenic Trail	Gulf Coast	71.52	0.00	97.0	0.00	97.0
National Capital Parks - East	National Capital Region	5.94	0.00	97.0	0.00	97.0
National Park of American Samoa	Pacific Island	16.66	0.00	97.0	0.00	97.0
Natural Bridges	Northern Colorado Plateau	11.56	0.00	97.0	0.00	97.0
Navajo	Southern Colorado Plateau	0.56	0.00	97.0	0.00	97.0
New River Gorge	Eastern Rivers and Mountains	109.98	0.00	97.0	0.00	97.0
Nez Perce	Upper Columbia Basin	5.39	0.00	97.0	0.00	97.0
Ninety Six	Cumberland Piedmont	1.50	0.00	97.0	0.00	97.0
Niobrara	Northern Great Plains	45.47	0.48	202.0	0.22	201.0
Noatak	Arctic	10280.90	88.18	233.0	9066.06	269.0
North Cascades	North Coast and Cascades	782.91	99.97	263.0	782.70	252.0
Obed	Appalachian Highlands	8.32	0.00	97.0	0.00	97.0
Ocmulgee	Southeast Coast	1.08	0.00	97.0	0.00	97.0
Olympic	North Coast and Cascades	1428.42	99.75	249.0	1424.79	259.0

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Oregon Caves	Klamath	0.73	0.00	97.0	0.00	97.0
Organ Pipe Cactus	Sonoran Desert	516.70	84.12	230.0	434.63	246.0
Ozark	Heartland	128.62	0.00	97.0	0.00	97.0
Padre Island	Gulf Coast	204.94	0.00	97.0	0.00	97.0
Palo Alto Battlefield	Gulf Coast	5.33	0.00	97.0	0.00	97.0
Pea Ridge	Heartland	6.67	0.00	97.0	0.00	97.0
Pecos	Southern Plains	10.20	0.00	97.0	0.00	97.0
Petersburg	Mid Atlantic	5.24	0.00	97.0	0.00	97.0
Petrified Forest	Southern Colorado Plateau	348.43	100.00	264.0	348.43	241.0
Petroglyph	Southern Colorado Plateau	11.25	0.00	97.0	0.00	97.0
Pictured Rocks	Great Lakes	115.12	0.00	97.0	0.00	97.0
Pinnacles	San Francisco Bay Area	42.42	62.29	219.0	26.42	215.0
Pipe Spring	Northern Colorado Plateau	0.06	0.00	97.0	0.00	97.0
Pipestone	Heartland	0.44	0.00	97.0	0.00	97.0
Point Reyes	San Francisco Bay Area	112.29	47.17	216.0	52.97	220.0
Prince William Forest	National Capital Region	17.33	0.00	97.0	0.00	97.0
Pu'uhonua o Honaunau	Pacific Island	0.66	0.00	97.0	0.00	97.0
Puukohola Heiau	Pacific Island	0.13	0.00	97.0	0.00	97.0
Rainbow Bridge	Southern Colorado Plateau	0.25	0.00	97.0	0.00	97.0
Redwood	Klamath	180.69	97.77	237.0	176.65	235.0
Richmond	Mid Atlantic	2.37	0.00	97.0	0.00	97.0
Rock Creek Park	National Capital Region	4.23	0.00	97.0	0.00	97.0
Rocky Mountain	Rocky Mountain	417.06	99.78	250.0	416.14	245.0
Russell Cave	Cumberland Piedmont	0.50	0.00	97.0	0.00	97.0
Sagamore Hill	Northeast Coastal and Barrier	0.11	0.00	97.0	0.00	97.0
Saguaro	Sonoran Desert	146.02	83.57	229.0	122.03	232.0

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Saint Croix	Great Lakes	152.70	0.00	97.0	0.00	97.0
Saint-Gaudens	Northeast Temperate	0.23	0.00	97.0	0.00	97.0
Salinas Pueblo Missions	Southern Colorado Plateau	1.66	0.00	97.0	0.00	97.0
San Antonio Missions	Gulf Coast	1.29	0.00	97.0	0.00	97.0
San Juan Island	North Coast and Cascades	2.69	0.00	97.0	0.00	97.0
Santa Monica Mountains	Mediterranean Coast	234.38	0.00	97.0	0.00	97.0
Saratoga	Northeast Temperate	4.49	0.00	97.0	0.00	97.0
Saugus Iron Works	Northeast Temperate	0.02	0.00	97.0	0.00	97.0
Scotts Bluff	Northern Great Plains	5.06	0.00	97.0	0.00	97.0
Sequoia	Sierra Nevada	635.63	99.94	256.0	635.28	250.0
Shenandoah	Mid Atlantic	301.99	99.46	243.0	300.38	239.0
Shiloh	Cumberland Piedmont	6.38	0.00	97.0	0.00	97.0
Sitka	Southeast Alaska	0.18	0.00	97.0	0.00	97.0
Sleeping Bear Dunes	Great Lakes	109.72	0.00	97.0	0.00	97.0
Stones River	Cumberland Piedmont	1.11	0.00	97.0	0.00	97.0
Sunset Crater Volcano	Southern Colorado Plateau	4.75	0.00	97.0	0.00	97.0
Tallgrass Prairie	Heartland	17.09	0.00	97.0	0.00	97.0
Theodore Roosevelt	Northern Great Plains	109.97	100.00	269.0	109.97	229.0
Thomas Stone	Northeast Coastal and Barrier	0.51	0.00	97.0	0.00	97.0
Timpanogos Cave	Northern Colorado Plateau	0.39	10.34	208.0	0.04	200.0
Timucaun Ecological and Historical Preserve	Southeast Coast	71.40	0.00	97.0	0.00	97.0
Tonto	Sonoran Desert	1.75	0.00	97.0	0.00	97.0
Tumacacori	Sonoran Desert	0.57	0.00	97.0	0.00	97.0
Tuzigoot	Sonoran Desert	1.27	0.00	97.0	0.00	97.0

Park Name	Network Name	Park Area (square miles)	Percent of Park Receiving Special Protection	Park Ranking for Percent of Park Receiving Special Protection	Area of Park Receiving Special Protection	Ranking for Area of Park Receiving Special Protection
Upper Delaware	Eastern Rivers and Mountains	86.17	0.00	97.0	0.00	97.0
Valley Forge	Mid Atlantic	5.39	0.00	97.0	0.00	97.0
Vanderbilt Mansion	Northeast Temperate	0.33	0.00	97.0	0.00	97.0
Vicksburg	Gulf Coast	2.58	0.00	97.0	0.00	97.0
Virgin Islands	South Florida Caribbean	23.07	100.00	266.0	23.07	212.0
Voyageurs	Great Lakes	320.18	100.00	267.0	320.18	240.0
Walnut Canyon	Southern Colorado Plateau	5.58	0.00	97.0	0.00	97.0
War in the Pacific	Pacific Island	2.98	0.00	97.0	0.00	97.0
Washita Battlefield	Southern Plains	0.49	0.00	97.0	0.00	97.0
Weir Farm	Northeast Temperate	0.09	0.00	97.0	0.00	97.0
Whiskeytown	Klamath	65.84	0.00	97.0	0.00	97.0
White Sands	Chihuahuan Desert	227.32	0.00	97.0	0.00	97.0
Whitman Mission	Upper Columbia Basin	0.16	0.00	97.0	0.00	97.0
Wilson's Creek	Heartland	3.73	0.00	97.0	0.00	97.0
Wind Cave	Northern Great Plains	44.26	100.00	270.0	44.26	218.0
Wolf Trap National Park for the Performing Arts	National Capital Region	0.21	0.00	97.0	0.00	97.0
Wrangell-St. Elias	Central Alaska	20588.98	73.55	223.0	15142.45	271.0
Wupatki	Southern Colorado Plateau	55.39	0.00	97.0	0.00	97.0
Yellowstone	Greater Yellowstone	3436.65	99.92	254.0	3434.03	263.0
Yosemite	Sierra Nevada	1164.65	100.00	268.0	1164.65	257.0
Yucca House	Southern Colorado Plateau	0.06	0.00	97.0	0.00	97.0
Yukon-Charley Rivers	Central Alaska	3940.33	0.00	97.0	0.00	97.0
Zion	Northern Colorado Plateau	232.40	99.15	239.0	230.43	236.0

Appendix B: Ranking Scores for Pollutant Exposure, Ecosystem Sensitivity, Park Protection, and Overall Risk for Each of the 271 I&M Parks

Network Name	Network Code	I&M Parks[1]	Park Code	Park Ranking[2]			
				Average of Pollutant Exposure	Average of Ecosystem Sensitivity	Average of Park Protection	Overall Risk
Cumberland Piedmont	CUPN	Abraham Lincoln Birthplace	ABLI	234.50	117.25	97	3.67
Northeast Temperate	NETN	Acadia	ACAD	132.25	192.92	229.5	4.33
Northern Great Plains	NGPN	Agate Fossil Beds	AGFO	101.88	118.67	97	2.67
Southwest Alaska	SWAN	Alagnak	ALAG	5.50	90.38	206	2.33
Southern Plains	SOPN	Alibates Flint Quarries	ALFL	158.13	96.25	97	2.67
Eastern Rivers and Mountains	ERMN	Allegheny Portage Railroad	ALPO	254.00	199.83	97	4.33
Pacific Island	PACN	American Memorial Park	AMME		113.50	97	3.00
Chihuahuan Desert	CHDN	Amistad	AMIS	89.88	98.58	97	2.33
Southwest Alaska	SWAN	***Aniakchak***	ANIA	4.00	139.25	97	2.67
National Capital Region	NCRN	Antietam	ANTI	243.63	159.75	97	4.33
Great Lakes	GLKN	***Apostle Islands***	APIS	108.88	163.92	97	3.67
Mid Atlantic	MIDN	Appomattox Court House	APCO	199.63	93.17	97	3.00
Northern Colorado Plateau	NCPN	***Arches***	ARCH	69.88	119.42	242	3.00
Heartland	HTLN	Arkansas Post	ARPO	167.25	75.25	97	2.33
Northeast Coastal and Barrier	NCBN	Assateague Island	ASIS	224.75	63.58	97	3.00
Southern Colorado Plateau	SCPN	Aztec Ruins	AZRU	123.75	83.42	97	2.33
Northern Great Plains	NGPN	***Badlands***	BADL	66.88	116.25	220.5	3.00
Southern Colorado Plateau	SCPN	Bandelier	BAND	84.38	147.00	220	3.67
Southern Plains	SOPN	Bent's Old Fort	BEOL	86.13	66.75	97	2.00
Arctic	ARCN	***Bering Land Bridge***	BELA	7.50	121.25	97	2.33
Chihuahuan Desert	CHDN	***Big Bend***	BIBE	57.25	150.17	255	3.33
South Florida / Caribbean	SFCN	***Big Cypress***	BICY	178.38	84.75	198.5	3.00
Upper Columbia Basin	UCBN	Big Hole	BIHO	29.63	108.92	97	2.33
Appalachian Highlands	APHN	***Big South Fork***	BISO	197.75	192.42	97	4.00

Network Name	Network Code	I&M Parks[1]	Park Code	Park Ranking[2]			
				Average of Pollutant Exposure	Average of Ecosystem Sensitivity	Average of Park Protection	Overall Risk
Gulf Coast	GULN	***Big Thicket***	BITH	199.50	97.92	97	3.00
Greater Yellowstone	GRYN	***Bighorn Canyon***	BICA	70.13	127.92	97	2.67
South Florida / Caribbean	SFCN	***Biscayne***	BISC	187.50	74.25	97	2.67
Northern Colorado Plateau	NCPN	Black Canyon of the Gunnison	BLCA	66.13	144.33	215.5	3.00
Appalachian Highlands	APHN	***Blue Ridge***	BLRI	201.75	244.83	205	4.33
Eastern Rivers and Mountains	ERMN	Bluestone	BLUE	198.00	210.50	97	4.00
Mid Atlantic	MIDN	Booker T. Washington	BOWA	186.88	83.75	97	2.67
Northeast Temperate	NETN	Boston Harbor Islands	BOHA	226.50	96.25	97	3.33
Northern Colorado Plateau	NCPN	Bryce Canyon	BRCA	46.38	146.50	234.5	3.33
South Florida / Caribbean	SFCN	Buck Island Reef	BUIS	197.00	74.50	97	2.67
Heartland	HTLN	***Buffalo***	BUFF	163.13	172.00	218	4.00
Mediterranean Coast	MEDN	Cabrillo	CABR	161.38	98.08	97	2.67
Southeast Coast	SECN	Canaveral	CANA	197.63	87.08	97	2.67
Southern Colorado Plateau	SCPN	***Canyon de Chelly***	CACH	92.63	128.75	97	3.00
Northern Colorado Plateau	NCPN	***Canyonlands***	CANY	67.75	133.92	247	3.33
Northeast Coastal and Barrier	NCBN	Cape Cod	CACO	214.00	152.58	97	3.67
Southeast Coast	SECN	Cape Hatteras	CAHA	185.25	80.25	97	2.67
Arctic	ARCN	***Cape Krusenstern***	CAKR	8.50	93.63	97	2.00
Southeast Coast	SECN	Cape Lookout	CALO	187.88	67.92	97	2.67
Northern Colorado Plateau	NCPN	***Capitol Reef***	CARE	69.75	146.83	242	3.33
Southern Plains	SOPN	Capulin Volcano	CAVO	59.38	102.58	97	2.00
Cumberland Piedmont	CUPN	Carl Sandburg Home	CARL	193.50	183.83	97	4.00
Chihuahuan Desert	CHDN	Carlsbad Caverns	CAVE	93.50	157.33	247.5	4.00
Sonoran Desert	SODN	Casa Grande Ruins	CAGR	109.25	64.92	97	2.33
Southeast Coast	SECN	Castillo de San Marcos	CASA	192.13	62.58	97	2.67
National Capital Region	NCRN	Catoctin Mountain	CATO	255.00	205.00	97	4.33
Northern Colorado Plateau	NCPN	Cedar Breaks	CEBR	62.50	146.00	198	3.00

Network Name	Network Code	I&M Parks[1]	Park Code	Park Ranking[2]			
				Average of Pollutant Exposure	Average of Ecosystem Sensitivity	Average of Park Protection	Overall Risk
Southern Colorado Plateau	SCPN	Chaco Culture	CHCU	104.63	112.75	97	2.67
Mediterranean Coast	MEDN	***Channel Islands***	CHIS	161.63	130.42	97	3.33
Southeast Coast	SECN	Chattahoochee River	CHAT	230.63	127.50	97	4.00
National Capital Region	NCRN	Chesapeake and Ohio Canal	CHOH	244.50	178.42	97	4.33
Cumberland Piedmont	CUPN	Chickamauga and Chattanooga	CHCH	224.25	199.50	97	4.33
Southern Plains	SOPN	Chickasaw	CHIC	154.63	99.08	97	2.67
Sonoran Desert	SODN	Chiricahua	CHIR	61.50	150.00	235.5	3.33
Upper Columbia Basin	UCBN	City of Rocks	CIRO	68.00	145.33	97	2.67
Northeast Coastal and Barrier	NCBN	Colonial	COLO	220.50	89.08	97	3.33
Northern Colorado Plateau	NCPN	Colorado	COLM	74.88	127.75	97	3.00
Southeast Coast	SECN	Congaree	COSW	193.63	87.92	217.5	3.33
Sonoran Desert	SODN	Coronado	CORO	71.38	103.08	196	2.33
Cumberland Piedmont	CUPN	Cowpens	COWP	197.75	80.08	97	2.67
Klamath	KLMN	***Crater Lake***	CRLA	87.13	172.00	240.5	4.00
Upper Columbia Basin	UCBN	***Craters of the Moon***	CRMO	68.38	78.17	216	2.00
Cumberland Piedmont	CUPN	Cumberland Gap	CUGA	194.13	223.50	97	4.00
Southeast Coast	SECN	Cumberland Island	CUIS	178.13	92.42	211	3.33
Northern Colorado Plateau	NCPN	Curecanti	CURE	58.00	167.50	97	3.00
Heartland	HTLN	Cuyahoga Valley	CUVA	263.50	140.58	97	4.00
Mojave Desert	MOJN	***Death Valley***	DEVA	72.63	161.83	246.5	3.67
Eastern Rivers and Mountains	ERMN	***Delaware Water Gap***	DEWA	235.00	194.25	97	4.33
Central Alaska	CAKN	***Denali***	DENA	22.50	159.00	246.5	3.67
Sierra Nevada	SIEN	Devils Postpile	DEPO	79.63	132.25	235	3.67
Northern Great Plains	NGPN	Devils Tower	DETO	83.75	116.83	97	2.67
Northern Colorado Plateau	NCPN	***Dinosaur***	DINO	81.00	153.00	97	3.00
South Florida / Caribbean	SFCN	***Dry Tortugas***	DRTO	186.50	74.10	97	2.67
North Coast and Cascades	NCCN	Ebey's Landing	EBLA	123.50	77.75	97	2.33

Network Name	Network Code	I&M Parks[1]	Park Code	Park Ranking[2]			
				Average of Pollutant Exposure	Average of Ecosystem Sensitivity	Average of Park Protection	Overall Risk
Heartland	HTLN	Effigy Mounds	EFMO	184.50	127.75	97	3.67
Mid Atlantic	MIDN	Eisenhower	EISE	255.63	103.58	97	3.33
Southern Colorado Plateau	SCPN	***El Malpais***	ELMA	91.63	90.25	202.5	2.67
Southern Colorado Plateau	SCPN	El Morro	ELMO	104.75	80.25	97	2.33
South Florida / Caribbean	SFCN	***Everglades***	EVER	175.38	97.92	260.5	3.67
Northeast Coastal and Barrier	NCBN	Fire Island	FIIS	243.88	81.92	209	3.33
Rocky Mountain	ROMN	Florissant Fossil Beds	FLFO	129.25	133.67	97	3.33
Sonoran Desert	SODN	Fort Bowie	FOBO	65.25	106.58	97	2.00
Southeast Coast	SECN	Fort Caroline	FOCA	208.63	67.42	97	2.67
Chihuahuan Desert	CHDN	Fort Davis	FODA	64.38	91.25	97	2.00
Cumberland Piedmont	CUPN	Fort Donelson	FODO	218.88	116.08	97	3.67
Southeast Coast	SECN	Fort Frederica	FOFR	181.75	68.25	97	2.67
Northern Great Plains	NGPN	Fort Laramie	FOLA	109.88	96.17	97	2.67
Southern Plains	SOPN	Fort Larned	FOLS	127.50	74.25	97	2.33
Southeast Coast	SECN	Fort Matanzas	FOMA	199.88	65.25	97	2.67
Eastern Rivers and Mountains	ERMN	Fort Necessity	FONE	257.75	167.92	97	4.33
San Francisco Bay Area	SFAN	Fort Point	FOPO	160.00	97.50	97	2.67
Southeast Coast	SECN	Fort Pulaski	FOPU	174.88	82.25	97	2.67
Southeast Coast	SECN	Fort Sumter	FOSU	205.00	64.08	97	2.67
Southern Plains	SOPN	Fort Union	FOUN	50.88	74.08	97	1.67
Northern Great Plains	NGPN	Fort Union Trading Post	FOUS	94.25	79.75	97	2.00
North Coast and Cascades	NCCN	Fort Vancouver	FOVA	148.00	72.42	97	2.33
Northern Colorado Plateau	NCPN	Fossil Butte	FOBU	99.63	114.08	97	2.67
Mid Atlantic	MIDN	Fredericksburg and Spotsylvania	FRSP	224.25	97.08	97	3.33
Eastern Rivers and Mountains	ERMN	Friendship Hill	FRHI	252.50	113.08	97	3.67
Arctic	ARCN	***Gates of the Arctic***	GAAR	19.00	167.00	250.5	3.67
Northeast Coastal and Barrier	NCBN	Gateway	GATE	255.00	98.75	97	3.33

Network Name	Network Code	I&M Parks[1]	Park Code	Park Ranking[2]			
				Average of Pollutant Exposure	Average of Ecosystem Sensitivity	Average of Park Protection	Overall Risk
Eastern Rivers and Mountains	ERMN	Gauley River	GARI	227.00	194.25	97	4.33
National Capital Region	NCRN	George Washington	GWMP	256.50	124.25	97	3.67
Northeast Coastal and Barrier	NCBN	George Washington Birthplace	GEWA	249.13	84.08	97	3.00
Heartland	HTLN	George Washington Carver	GWCA	186.63	73.75	97	2.67
Mid Atlantic	MIDN	Gettysburg	GETT	257.25	113.42	97	3.67
Sonoran Desert	SODN	Gila Cliff Dwellings	GICL	60.38	112.33	199.5	2.67
Rocky Mountain	ROMN	***Glacier***	GLAC	77.00	231.50	258.5	4.00
Southeast Alaska	SEAN	***Glacier Bay***	GLBA	9.00	149.75	245.5	3.33
Southern Colorado Plateau	SCPN	***Glen Canyon***	GLCA	67.88	131.75	196	3.00
San Francisco Bay Area	SFAN	***Golden Gate***	GOGA	169.25	144.08	197.5	3.67
Northern Colorado Plateau	NCPN	Golden Spike	GOSP	98.38	104.42	97	2.33
Southern Colorado Plateau	SCPN	***Grand Canyon***	GRCA	75.75	191.00	251.5	4.00
Great Lakes	GLKN	Grand Portage	GRPO	81.63	156.25	97	3.00
Greater Yellowstone	GRYN	***Grand Teton***	GRTE	93.63	178.67	249	4.00
Rocky Mountain	ROMN	Grant-Kohrs Ranch	GRKO	32.13	84.92	97	1.67
Mojave Desert	MOJN	***Great Basin***	GRBA	32.00	160.00	97	3.00
Rocky Mountain	ROMN	***Great Sand Dunes***	GRSA	65.25	172.33	224	3.67
Appalachian Highlands	APHN	***Great Smoky Mountains***	GRSM	196.75	241.17	245.5	4.67
Chihuahuan Desert	CHDN	***Guadalupe Mountains***	GUMO	84.88	150.83	240	3.67
Cumberland Piedmont	CUPN	Guilford Courthouse	GUCO	222.13	78.42	97	3.00
Gulf Coast	GULN	***Gulf Islands***	GUIS	188.75	75.42	207.5	3.00
Upper Columbia Basin	UCBN	Hagerman Fossil Beds	HAFO	79.00	110.25	97	2.67
Pacific Island	PACN	Haleakala	HALE	105.00	161.20	226	4.33
National Capital Region	NCRN	Harpers Ferry	HAFE	240.38	181.08	97	4.33
Pacific Island	PACN	***Hawaii Volcanoes***	HAVO	86.50	149.40	255.5	3.67
Heartland	HTLN	Herbert Hoover	HEHO	197.00	81.92	97	2.67
Northeast Temperate	NETN	Home of Franklin D. Roosevelt	HOFR	225.25	114.42	97	3.67

Network Name	Network Code	I&M Parks[1]	Park Code	Park Ranking[2]			
				Average of Pollutant Exposure	Average of Ecosystem Sensitivity	Average of Park Protection	Overall Risk
Heartland	HTLN	Homestead	HOME	183.88	87.17	97	3.00
Heartland	HTLN	Hopewell Culture	HOCU	254.88	95.75	97	3.33
Mid Atlantic	MIDN	Hopewell Furnace	HOFU	261.50	123.42	97	3.67
Southeast Coast	SECN	Horseshoe Bend	HOBE	203.88	107.08	97	3.33
Heartland	HTLN	Hot Springs	HOSP	156.88	114.25	97	3.00
Northern Colorado Plateau	NCPN	Hovenweep	HOVE	106.38	91.75	97	2.67
Southern Colorado Plateau	SCPN	Hubbell Trading Post	HUTR	96.88	73.25	97	2.00
Great Lakes	GLKN	Indiana Dunes	INDU	238.38	111.58	97	3.67
Great Lakes	GLKN	***Isle Royale***	ISRO	82.88	132.92	257.5	3.67
Gulf Coast	GULN	Jean Lafitte	JELA	200.13	80.92	97	2.67
Northern Great Plains	NGPN	Jewel Cave	JECA	91.63	128.83	97	3.00
Upper Columbia Basin	UCBN	John Day Fossil Beds	JODA	57.25	123.08	97	2.33
San Francisco Bay Area	SFAN	John Muir	JOMU	181.38	101.58	97	3.00
Eastern Rivers and Mountains	ERMN	Johnstown Flood	JOFL	254.00	165.08	97	4.33
Mojave Desert	MOJN	***Joshua Tree***	JOTR	112.88	130.58	243.5	4.00
Pacific Island	PACN	Kalaupapa	KALA	218.50	122.30	97	3.67
Pacific Island	PACN	Kaloko-Honokohau	KAHO	95.50	85.10	97	2.00
Southwest Alaska	SWAN	***Katmai***	KATM	8.50	156.50	247.5	3.67
Southwest Alaska	SWAN	***Kenai Fjords***	KEFJ	24.00	153.00	200	3.00
Southeast Coast	SECN	Kennesaw Mountain	KEMO	243.75	123.00	97	3.67
Sierra Nevada	SIEN	***Kings Canyon***	KICA	86.50	239.00	254.5	4.00
Cumberland Piedmont	CUPN	Kings Mountain	KIMO	203.13	96.58	97	3.00
Southeast Alaska	SEAN	Klondike Gold Rush	KLGO	10.00	153.75	97	2.67
Northern Great Plains	NGPN	Knife River Indian Villages	KNRI	144.50	82.25	97	2.33
Arctic	ARCN	***Kobuk Valley***	KOVA	13.00	152.00	223.5	3.33
Southwest Alaska	SWAN	***Lake Clark***	LACL	15.00	168.25	242.5	3.67
Mojave Desert	MOJN	***Lake Mead***	LAME	73.25	153.83	226.5	3.67

Network Name	Network Code	I&M Parks[1]	Park Code	Park Ranking[2]			
				Average of Pollutant Exposure	Average of Ecosystem Sensitivity	Average of Park Protection	Overall Risk
Southern Plains	SOPN	Lake Meredith	LAMR	157.50	109.58	97	3.00
Upper Columbia Basin	UCBN	***Lake Roosevelt***	LARO	55.13	113.58	97	2.33
Klamath	KLMN	***Lassen Volcanic***	LAVO	83.13	221.50	239.5	4.00
Klamath	KLMN	Lava Beds	LABE	45.13	79.25	219.5	2.33
North Coast and Cascades	NCCN	Lewis and Clark	LEWI	147.63	101.92	97	2.67
Heartland	HTLN	Lincoln Boyhood	LIBO	247.63	97.25	97	3.33
Rocky Mountain	ROMN	Little Bighorn Battlefield	LIBI	81.88	83.58	97	2.00
Cumberland Piedmont	CUPN	Little River Canyon	LIRI	235.25	201.50	97	4.33
Southern Plains	SOPN	Lyndon B. Johnson	LYJO	157.13	82.25	97	2.33
Cumberland Piedmont	CUPN	Mammoth Cave	MACA	232.38	138.92	230	4.67
National Capital Region	NCRN	Manassas	MANA	242.13	109.58	97	3.67
Mojave Desert	MOJN	Manzanar	MANZ	60.38	86.42	97	1.67
Northeast Temperate	NETN	Marsh-Billings-Rockefeller	MABI	160.00	168.42	97	3.67
Southern Colorado Plateau	SCPN	Mesa Verde	MEVE	115.25	153.67	234	4.00
Northeast Temperate	NETN	Minute Man	MIMA	210.00	147.58	97	3.67
Great Lakes	GLKN	Mississippi	MISS	199.50	123.75	97	3.33
Northern Great Plains	NGPN	***Missouri***	MNRR	153.38	113.42	97	3.00
Mojave Desert	MOJN	***Mojave***	MOJA	98.63	143.33	235.5	3.67
National Capital Region	NCRN	Monocacy	MONO	253.50	116.58	97	3.67
Sonoran Desert	SODN	Montezuma Castle	MOCA	89.63	90.92	97	2.33
Southeast Coast	SECN	Moores Creek	MOCR	217.00	72.92	97	3.00
Northeast Temperate	NETN	Morristown	MORR	247.25	174.25	97	4.33
North Coast and Cascades	NCCN	***Mount Rainier***	MORA	138.13	236.00	249	4.33
Northern Great Plains	NGPN	Mount Rushmore	MORU	84.00	101.08	197.5	2.67
San Francisco Bay Area	SFAN	Muir Woods	MUWO	184.75	114.75	97	3.33
Gulf Coast	GULN	Natchez Trace Parkway and National Scenic Trail	NATR	188.50	148.50	97	3.67
National Capital Region	NCRN	National Capital Parks - East	NACE	260.13	132.33	97	4.00

Network Name	Network Code	I&M Parks[1]	Park Code	Park Ranking[2]			
				Average of Pollutant Exposure	Average of Ecosystem Sensitivity	Average of Park Protection	Overall Risk
Pacific Island	PACN	National Park of American Samoa	NPSA		113.50	97	3.00
Northern Colorado Plateau	NCPN	Natural Bridges	NABR	74.00	113.25	97	2.67
Southern Colorado Plateau	SCPN	Navajo	NAVA	67.38	109.92	97	2.33
Eastern Rivers and Mountains	ERMN	***New River Gorge***	NERI	218.75	223.17	97	4.33
Upper Columbia Basin	UCBN	Nez Perce	NEPE	57.75	118.33	97	2.33
Cumberland Piedmont	CUPN	Ninety Six	NISI	185.88	86.92	97	2.67
Northern Great Plains	NGPN	Niobrara	NIOB	98.63	109.42	201.5	3.00
Arctic	ARCN	***Noatak***	NOAT	13.00	152.50	251	3.33
North Coast and Cascades	NCCN	***North Cascades***	NOCA	127.00	237.50	257.5	4.33
Appalachian Highlands	APHN	Obed	OBRI	203.88	181.08	97	4.00
Southeast Coast	SECN	Ocmulgee	OCMU	203.63	72.08	97	2.67
North Coast and Cascades	NCCN	***Olympic***	OLYM	146.63	191.83	254	4.33
Klamath	KLMN	Oregon Caves	ORCA	99.88	105.08	97	2.33
Sonoran Desert	SODN	***Organ Pipe Cactus***	ORPI	70.88	119.42	238	3.00
Heartland	HTLN	***Ozark***	OZAR	175.75	122.58	97	3.33
Gulf Coast	GULN	***Padre Island***	PAIS	148.13	63.08	97	2.33
Gulf Coast	GULN	Palo Alto Battlefield	PAAL	124.88	62.92	97	2.33
Heartland	HTLN	Pea Ridge	PERI	195.38	119.67	97	3.33
Southern Plains	SOPN	Pecos	PECO	73.38	130.67	97	3.00
Mid Atlantic	MIDN	Petersburg	PETE	227.88	104.25	97	3.33
Southern Colorado Plateau	SCPN	***Petrified Forest***	PEFO	102.13	110.25	252.5	3.33
Southern Colorado Plateau	SCPN	Petroglyph	PETR	82.00	96.42	97	2.33
Great Lakes	GLKN	***Pictured Rocks***	PIRO	122.13	178.08	97	3.67
San Francisco Bay Area	SFAN	Pinnacles	PINN	149.25	150.17	217	3.67
Northern Colorado Plateau	NCPN	Pipe Spring	PISP	50.63	84.08	97	1.67
Heartland	HTLN	Pipestone	PIPE	167.25	104.33	97	2.67
San Francisco Bay Area	SFAN	***Point Reyes***	PORE	176.63	122.75	218	3.67

Network Name	Network Code	I&M Parks[1]	Park Code	Park Ranking[2]			
				Average of Pollutant Exposure	Average of Ecosystem Sensitivity	Average of Park Protection	Overall Risk
National Capital Region	NCRN	Prince William Forest	PRWI	242.75	123.92	97	3.67
Pacific Island	PACN	Pu'uhonua o Honaunau	PUHO	85.50	97.30	97	2.33
Pacific Island	PACN	Puukohola Heiau	PUHE	97.00	94.10	97	2.33
Southern Colorado Plateau	SCPN	Rainbow Bridge	RABR	51.13	112.58	97	2.33
Klamath	KLMN	***Redwood***	REDW	104.25	133.42	236	3.67
Mid Atlantic	MIDN	Richmond	RICH	233.00	87.25	97	3.33
National Capital Region	NCRN	Rock Creek Park	ROCR	258.25	125.25	97	3.67
Rocky Mountain	ROMN	***Rocky Mountain***	ROMO	130.00	235.50	247.5	4.33
Cumberland Piedmont	CUPN	Russell Cave	RUCA	217.63	129.42	97	4.00
Northeast Coastal and Barrier	NCBN	Sagamore Hill	SAHI	251.50	102.25	97	3.33
Sonoran Desert	SODN	***Saguaro***	SAGU	91.88	156.33	230.5	3.67
Great Lakes	GLKN	***Saint Croix***	SACN	164.50	221.83	97	3.67
Northeast Temperate	NETN	Saint-Gaudens	SAGA	165.13	171.25	97	3.67
Southern Colorado Plateau	SCPN	Salinas Pueblo Missions	SAPU	56.88	94.08	97	2.00
Gulf Coast	GULN	San Antonio Missions	SAAN	173.00	99.50	97	2.67
North Coast and Cascades	NCCN	San Juan Island	SAJH	142.00	87.08	97	2.33
Mediterranean Coast	MEDN	***Santa Monica Mountains***	SAMO	180.00	134.42	97	3.67
Northeast Temperate	NETN	Saratoga	SARA	173.25	112.92	97	3.00
Northeast Temperate	NETN	Saugus Iron Works	SAIR	223.50	125.42	97	4.00
Northern Great Plains	NGPN	Scotts Bluff	SCBL	115.13	88.75	97	2.67
Sierra Nevada	SIEN	***Sequoia***	SEQU	98.75	237.33	253	4.00
Mid Atlantic	MIDN	***Shenandoah***	SHEN	223.75	231.67	241	5.00
Cumberland Piedmont	CUPN	Shiloh	SHIL	191.50	90.92	97	3.00
Southeast Alaska	SEAN	Sitka	SITK	7.00	88.88	97	2.00
Great Lakes	GLKN	***Sleeping Bear Dunes***	SLBE	151.38	130.58	97	3.33
Cumberland Piedmont	CUPN	Stones River	STRI	209.75	84.25	97	2.67
Southern Colorado Plateau	SCPN	Sunset Crater Volcano	SUCR	81.38	92.92	97	2.33

Network Name	Network Code	I&M Parks[1]	Park Code	Park Ranking[2]			
				Average of Pollutant Exposure	Average of Ecosystem Sensitivity	Average of Park Protection	Overall Risk
Heartland	HTLN	Tallgrass Prairie	TAPR	180.75	142.50	97	3.67
Northern Great Plains	NGPN	***Theodore Roosevelt***	THRO	126.25	119.08	249	3.67
Northeast Coastal and Barrier	NCBN	Thomas Stone	THST	251.00	90.92	97	3.33
Northern Colorado Plateau	NCPN	Timpanogos Cave	TICA	120.63	114.75	204	3.33
Southeast Coast	SECN	Timucaun Ecological and Historical Preserve	TIMU	191.13	95.58	97	3.00
Sonoran Desert	SODN	Tonto	TONT	106.63	114.58	97	3.00
Sonoran Desert	SODN	Tumacacori	TUMA	73.63	74.42	97	2.00
Sonoran Desert	SODN	Tuzigoot	TUZI	81.50	96.58	97	2.33
Eastern Rivers and Mountains	ERMN	Upper Delaware	UPDE	213.88	193.58	97	4.00
Mid Atlantic	MIDN	Valley Forge	VAFO	263.00	116.42	97	3.67
Northeast Temperate	NETN	Vanderbilt Mansion	VAMA	217.00	122.58	97	3.67
Gulf Coast	GULN	Vicksburg	VICK	153.38	93.75	97	2.67
South Florida / Caribbean	SFCN	Virgin Islands	VIIS	202.50	121.10	239	4.00
Great Lakes	GLKN	***Voyageurs***	VOYA	124.88	167.42	253.5	4.33
Southern Colorado Plateau	SCPN	Walnut Canyon	WACA	89.63	111.58	97	2.67
Pacific Island	PACN	War in the Pacific	WAPA		113.50	97	3.00
Southern Plains	SOPN	Washita Battlefield	WABA	133.50	72.50	97	2.33
Northeast Temperate	NETN	Weir Farm	WEFA	245.88	146.08	97	4.00
Klamath	KLMN	Whiskeytown	WHIS	91.38	145.67	97	3.00
Chihuahuan Desert	CHDN	***White Sands***	WHSA	52.63	92.92	97	2.00
Upper Columbia Basin	UCBN	Whitman Mission	WHMI	96.88	80.08	97	2.00
Heartland	HTLN	Wilson's Creek	WICR	162.00	99.08	97	2.67
Northern Great Plains	NGPN	Wind Cave	WICA	86.38	161.83	244	4.00
National Capital Region	NCRN	Wolf Trap National Park for the Performing Arts	WOTR	258.50	107.08	97	3.67
Central Alaska	CAKN	***Wrangell-St. Elias***	WRST	13.00	164.75	247	3.67
Southern Colorado Plateau	SCPN	Wupatki	WUPA	72.00	107.58	97	2.33

Network Name	Network Code	I&M Parks[1]	Park Code	Park Ranking[2]			
				Average of Pollutant Exposure	Average of Ecosystem Sensitivity	Average of Park Protection	Overall Risk
Greater Yellowstone	GRYN	***Yellowstone***	YELL	76.38	226.33	258.5	4.00
Sierra Nevada	SIEN	***Yosemite***	YOSE	112.00	236.83	262.5	4.33
Southern Colorado Plateau	SCPN	Yucca House	YUHO	123.50	85.08	97	2.33
Central Alaska	CAKN	***Yukon-Charley Rivers***	YUCH	27.00	155.25	97	2.67
Northern Colorado Plateau	NCPN	***Zion***	ZION	62.50	137.75	237.5	3.33

[1] Park name is printed in bold italic for parks larger than 100 square miles.

[2] Ranges of rankings were as follows:
Pollutant Exposure: 4.0–263.5
Ecosystem Sensitivity: 62.6–244.8
Park Protection: 97.0–262.5
Overall Risk: 1.7–5.0

The Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

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