Section B:
Human Health and Environmental Benefits

Overview of the Assessment

This assessment analyzes the impacts of the 2003 Clear Skies Act. It compares air quality, atmospheric deposition, and ecosystem conditions projected to occur under Clear Skies to current conditions and to the Base Case (conditions expected to occur in the future under the proposed Nonroad Diesel Vehicle Rule and EPA and state regulations that have been finalized but not necessarily fully implemented).

Specifically, this assessment analyzes the effects of reducing power plant emissions on multiple human health and environmental issues, including:

- Fine Particles ($PM_{2.5}$)
- Ozone
- Visibility
- Sulfur and Nitrogen Deposition to Sensitive Ecosystems
- Freshwater Acidification
- Mercury Emissions
- Mercury Deposition

The assessment also estimates monetized benefits due to reduced $PM_{2.5}$ and ozone concentrations, including improvements in human health and visibility.

Summary of Results

The Clear Skies Act would improve human health, visibility, and a diverse range of ecosystems by further reducing emissions and deposition of SO_2, NOx, and Hg.

By 2020, the benefits of reductions in fine particles and ozone are estimated to be $113 billion annually (1999$), including:

- $110 billion in annual human health benefits. This is a result of annually avoiding:
  - 14,100 premature deaths;
  - 8,800 new cases of chronic bronchitis;
  - 23,000 non-fatal heart attacks;
  - 30,000 total hospitalizations and emergency room visits for cardiovascular and respiratory causes;
    - Included in this total are 15,000 fewer hospital and emergency room visits for asthma attacks.
  - 12.5 million days with respiratory-related symptoms, including lost work days, restricted activity days, and school absences.
    - Included in this total are approximately 180,000 fewer asthma attacks
- An alternative estimate projects over 8,400 premature deaths prevented and $21 billion in health benefits annually by 2020.
- $3 billion in annual visibility benefits from improving visibility at select National Parks and Wilderness Areas.

By 2010, reductions in fine particles and ozone are estimated to result in substantial early benefits of $54 billion, including 7,900 fewer premature deaths, annually.

- An alternative estimate projects 4,700 fewer premature deaths and $10 billion annually in health benefits by 2010.

There are additional health and environmental benefits, such as reduced human exposure to mercury, fewer acidified lakes, and reduced nitrogen loads to sensitive ecosystems that cannot currently be quantified and/or monetized but are nevertheless expected to be significant.

Summary of Results *cont'd*

By 2020, Clear Skies is expected to:

- bring 35 additional counties, home to approximately 12 million people, into attainment with the new fine particle standard as compared to existing programs (Base Case). The remaining 8 eastern counties are expected to move closer to attainment.
- bring 3 additional counties, home to 6 million people, into attainment with the new ozone standard as compared to existing programs (Base Case). The remaining counties are expected to move closer to attainment.

Compared to current conditions, by 2020 the Clear Skies Act, along with implementation of existing programs, would:

- Reduce $PM_{2.5}$ concentrations in large portions of the East and Midwest by up to 25%;
- Perceptibly improve visibility in a large portion of the Eastern U.S. by 2-3 deciviews from current levels;
- Reduce sulfur deposition (one component of acid deposition) over much of the sensitive eastern U.S. by 30-60%;
- Reduce nitrogen deposition (the other component of acid deposition as well as a source of contamination for many coastal waters) over much of the sensitive eastern U.S., including coastal areas, by up to 50%; and
- Virtually eliminate chronic acidity -- the most serious form of acidification -- in Northeastern lakes (eliminating it in lakes in Adirondack Park) and slow further deterioration of acidic Southeastern streams.

Compared to the Base Case in 2020, Clear Skies would:

- Reduce fine particle concentrations in much of the East and Midwest by up to 25%;
- Perceptibly improve visibility throughout the East and Midwest;
- Reduce sulfur deposition to sensitive ecosystems in the East by more than 30%; and
- Reduce nitrogen deposition across the East, Midwest, and portions of the West by up to 20%.

Air Quality Modeling: Base Case and Clear Skies

What is included in the Base Case?

The Base Case includes all finalized EPA and state regulations that are expected to be in effect in 2010 and 2020. It includes such recent actions as the:

- Title IV Acid Rain Program for controlling SO_2 and NOx from electric generating units
- NOx SIP Call
- Tier 2 rule for new cars and light trucks
- Heavy Duty Diesel truck rules for 2004 and 2007 covering new vehicles
- Proposed Nonroad Diesel Vehicle Rule
- Additional state regulatory requirements finalized by March 2003

What is not included in the air quality modeling Base Case?

The air quality Base Case does not include:

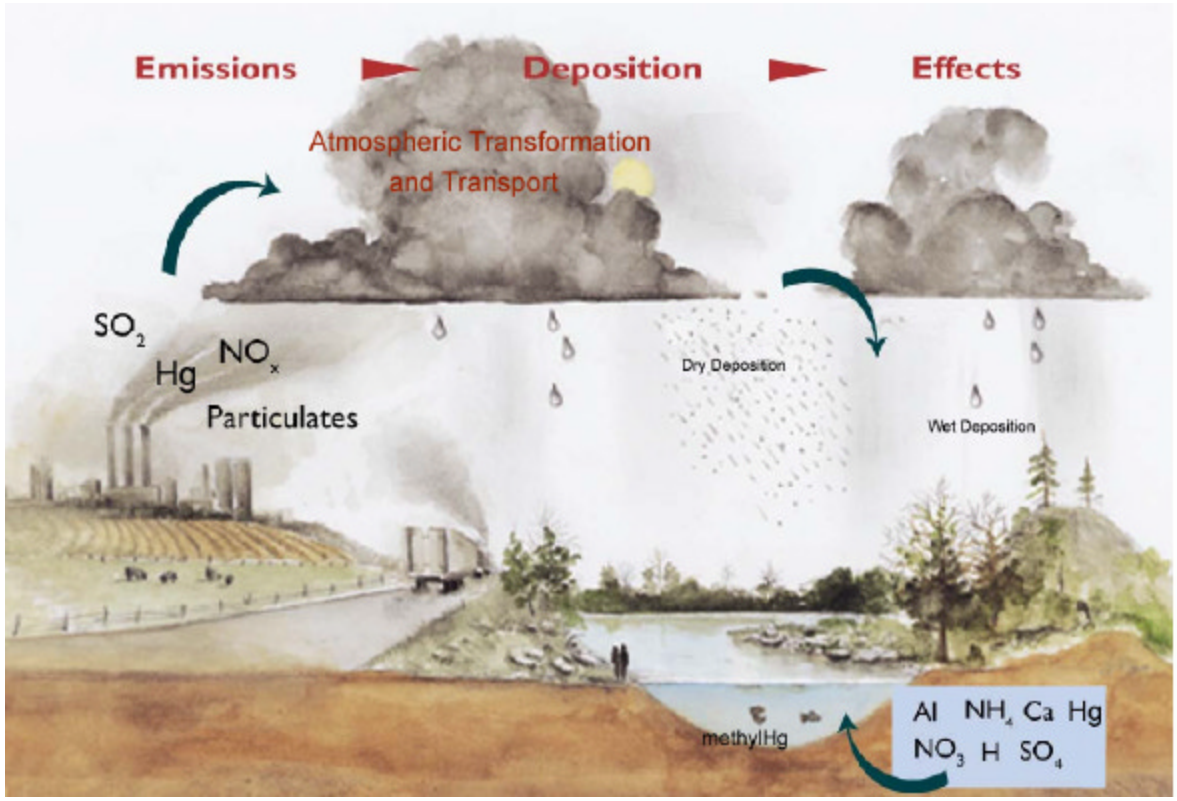
- Other planned major regulations that the EPA will pursue in addition to the Clear Skies Act to lower emissions across the country.
- Voluntary emissions reduction programs, such as the diesel retrofit program, and pending federal enforcement actions whose results are difficult to predict.
- Additions to State Implementation Plans to ensure compliance with the NAAQS or some *very* recent/pending state laws (finalized after March 2003), such as the one in New York State, that address air pollution.

What is included in the Clear Skies Case?

The Clear Skies Case includes the emissions from all other sectors projected with the Base Case as well as the projected emission reductions in SO_2, NOx, and mercury that would be achieved by Clear Skies. The air quality and benefits results presented are based on modeling the Clear Skies mercury cap without triggering the safety valve. The timing and geographic distribution of SO_2 and NOx emissions is not expected to be significantly different if the safety valve is triggered; mercury emissions are illustrative of what is expected to occur as mercury removal technologies improve in the future.

Overview of SO_2, NOx, and Mercury Emissions, Transport, and Transformation

- When emitted into the atmosphere, SO_2, NO_x, and mercury and the compounds they form through chemical reactions in the atmosphere can travel long distances.
- These chemical compounds take the form of tiny solid particles or liquid droplets and can remain in the air for days or even years.
- These and other pollutants can return to the earth through the processes of wet and dry atmospheric deposition.
- Wet deposition removes gases and particles in the atmosphere and deposits them to the Earth's surface in rain, sleet, snow, and fog.



Graphic modified from “Acid Rain Revisited,” Hubbard Brook Research Foundation, 2001

- Dry deposition is the deposition of particles and gases to land and water surfaces without precipitation.
- Depending on the chemical form in which it is emitted, mercury is a pollutant of concern at local, regional, and global scales. Mercury emissions in the ionic form are prone to deposit closest to their source.

An Integrated Multipollutant Approach Will Address Numerous Effects of SO_2, NOx, and Hg Emissions

Effects of Nitrogen Oxides (NOx)

- Contributes to premature death and serious respiratory and cardiovascular illness (e.g., asthma, chronic bronchitis, heart attacks) due to fine particles.
- Lowers worker productivity due to ozone.
- Acidifies surface water, reducing biodiversity and killing fish.
- Damages forests through direct impacts on leaves and needles, and by soil acidification and depletion of soil nutrients.
- Damages forest ecosystems, trees, ornamental plants, and crops through ozone formation.
- Contributes to coastal eutrophication, killing fish and shellfish.
- Contributes to decreased visibility (regional haze) and “brown clouds” in some major western cities.
- Speeds weathering of monuments, buildings, and other stone and metal structures.

Effects of Sulfur Dioxide (SO_2)

- Contributes to premature death and serious respiratory and cardiovascular illness (e.g., asthma, chronic bronchitis, heart attacks) due to fine particles.
- Acidifies surface water, reducing biodiversity and killing fish.
- Damages forests through direct impacts on leaves and needles, and by soil acidification and depletion of soil nutrients.
- Contributes to decreased visibility (regional haze).
- Speeds weathering of monuments, buildings, and other stone and metal structures.

Effects of Mercury (Hg)

- Impairs cognitive and motor skills with children of women who consume large amounts of fish during pregnancy being at the highest risk.
- Increases risk of cardiovascular effects (blood pressure regulation, heart rate variability and heart coronary heart disease) in children and adults.
- Impairs reproductive, immune and endocrine systems.
- Causes adverse effects, including reproductive and neurological effects, in loons, mink, otter, and other fish-eating animals.
- Bioaccumulates so that the concentrations in the fish and animals who eat fish are many times the concentration of mercury in the water.

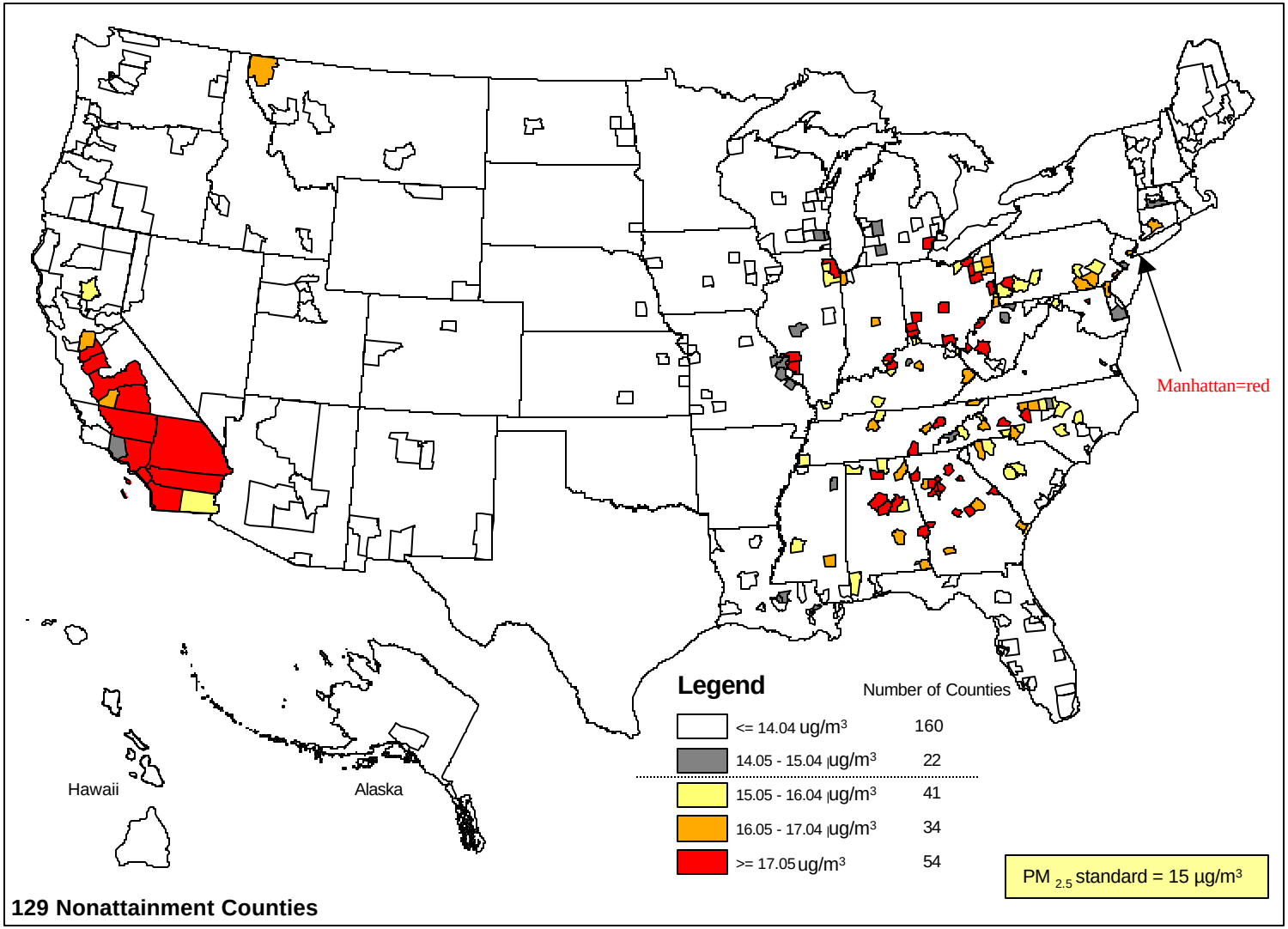
Fine Particles ($PM_{2.5}$) Harm Human Health

- Particulate matter is the term used for a mixture of solid particles and liquid droplets found in the air; fine particles are smaller than 2.5 micrometers (millionths of a meter) in diameter ($PM_{2.5}$).
- Power plants emit particles directly into the air, but the major contribution of power plant emissions to fine particulate matter air pollution is the emissions of SO_2 and NOx, which are converted into sulfate and nitrate particles in the atmosphere and can be transported for hundreds of miles.
- The health effects of exposure to fine particles include:
  - Increased premature deaths, primarily in the elderly and those with heart or lung disease;
  - Aggravation of respiratory and cardiovascular illness, leading to hospitalizations and emergency room visits, particularly in children, the elderly, and individuals with heart or lung conditions;
  - Decreased lung function and symptomatic effects such as those associated with acute bronchitis, particularly in children and asthmatics;
  - New cases of chronic bronchitis and new heart attacks;
  - Increased work loss days, school absences, and emergency room visits; and
  - Changes to lung structure and natural defense mechanisms.

Ozone (Smog) Harms Human Health and Vegetation

- Nitrogen oxides and volatile organic compounds react in the atmosphere in the presence of sunlight to form ground-level ozone.
- Ground-level ozone is a major component of smog in our cities and other areas of the country. Though naturally-occurring ozone in the stratosphere provides a protective layer high above the earth, the ozone that we breathe at ground level worsens or causes respiratory illness and other health and environmental problems.
- Health and environmental effects from high levels of ozone include:
  - Moderate to large (more than 20%) decreases in lung function resulting in difficulty in breathing, shortness of breath, and other symptoms;
  - Respiratory symptoms such as those associated with bronchitis (e.g., aggravated coughing and chest pain);
  - Increased respiratory problems (e.g. aggravation of asthma, susceptibility to respiratory infection), which often result in hospital admissions and emergency room visits;
  - Reduced productivity for workers in outdoor jobs;
  - Repeated exposure to ozone could result in chronic inflammation and irreversible structural changes in the lungs that can lead to premature aging of the lungs and other long-term respiratory illnesses; and
  - Damage to forest ecosystems, trees and ornamental plants, and crops.

Current Fine Particle ($PM_{2.5}$) Air Quality

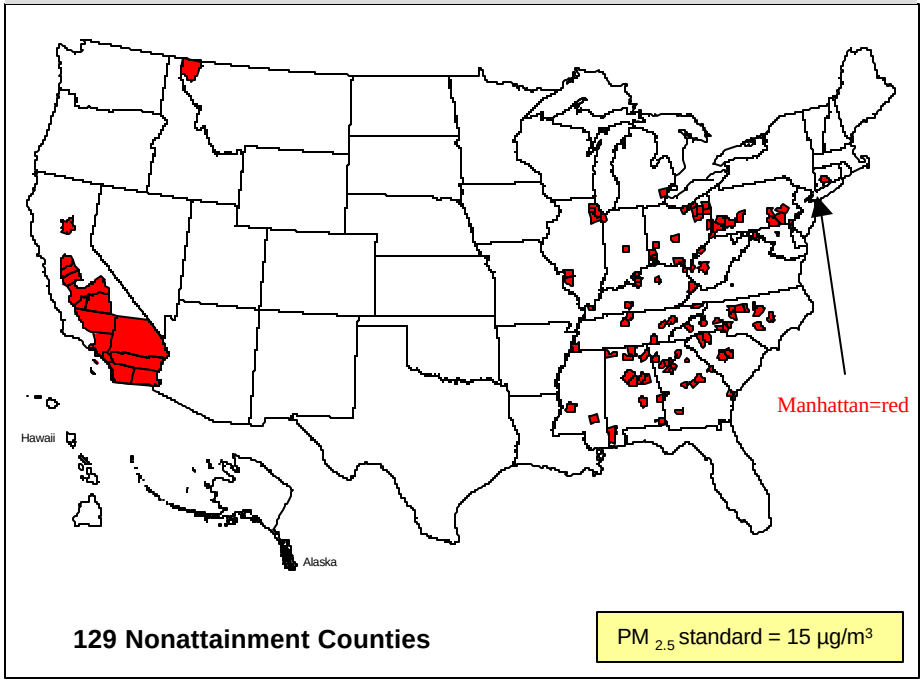


- **There are 129 counties nationwide (114 counties in the East) that exceed the annual fine particle standard of 15 µ/m³.**
- **65 million people (43 million people in the East) live in counties that would not meet this standard.**

Note: Based on 1999-2001 monitoring data of counties with monitors that have three years of complete data.

Clear Skies with Other Air Programs Would Substantially Improve Fine Particle Attainment over the Next Two Decades

Counties Exceeding the Annual Fine Particle Standards in 2001

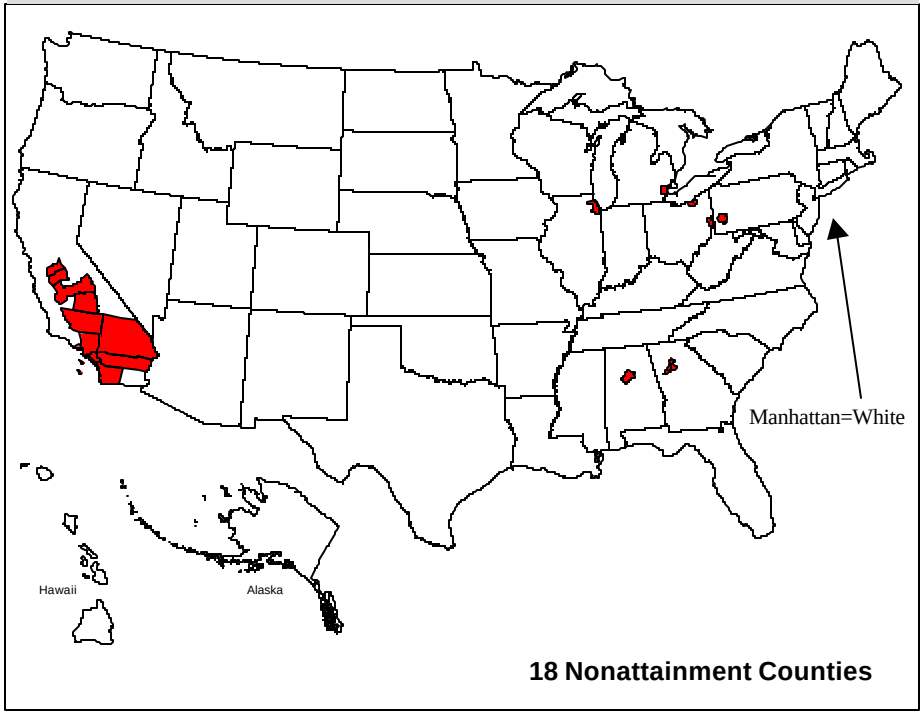


- **There are 129 counties nationwide (114 counties in the East) that are currently estimated to exceed the annual fine particle standard of 15 µ/m^3.**
  - **65 million people (43 million people in the East) currently live in counties that would not meet the standard**.

Most counties would be brought into attainment with the $PM_{2.5}$ standard by 2020:

- **Clear Skies and existing programs will bring 111 counties (home to approximately 32 million people) into attainment with the fine particle standard (compared to current conditions).**

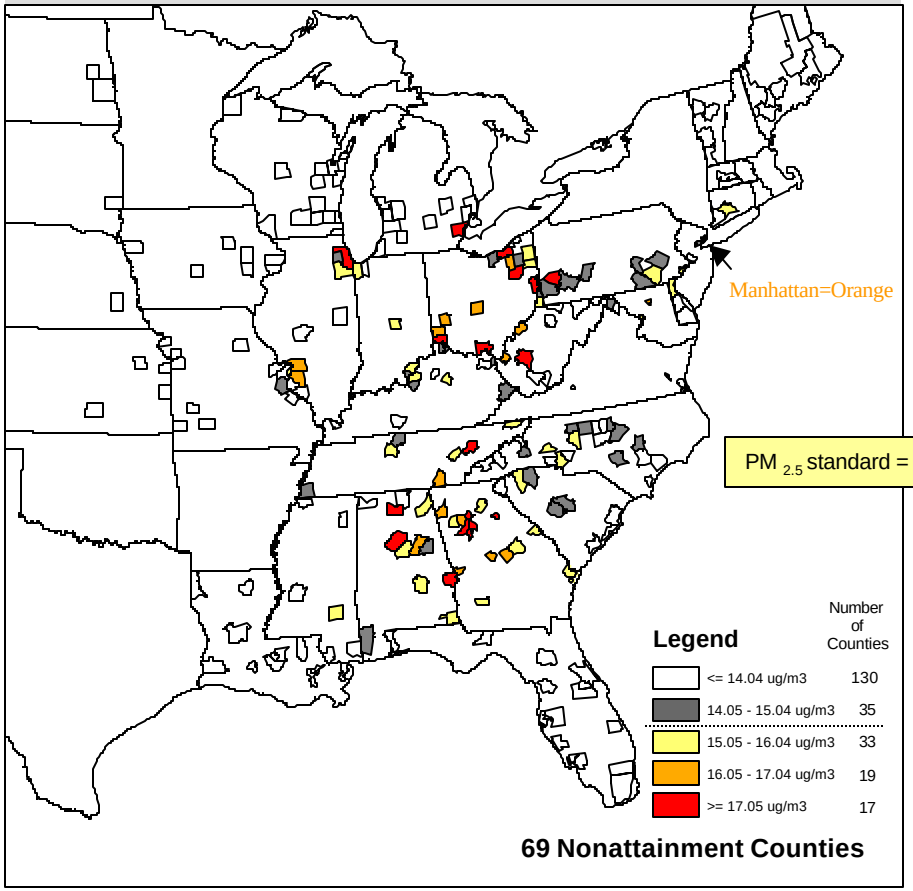
Remaining Counties Projected to Exceed the Annual Fine Particle Standards with Clear Skies and the Base Case in 2020



Notes: Based on 1999-2001 data of counties with monitors that have three years of complete data. Additional federal and state programs must bring all counties into attainment by 2016 at the latest. The methodology used to predict nonattainment status in the West is different than that used for the East.

Clear Skies Achieves Early Benefits by Bringing More Areas into Attainment with the $PM_{2.5}$ Standard in 2010

Remaining Counties Projected to Exceed the Annual Fine Particle Standards under the Base Case in 2010



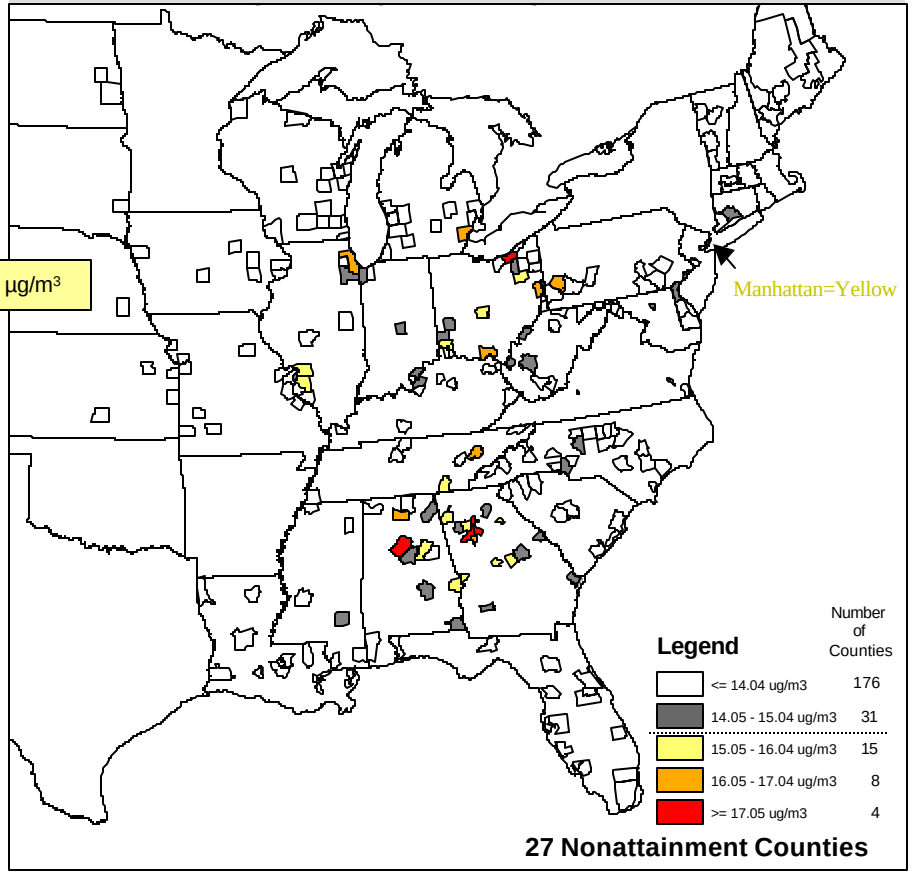
$PM_{2.5}$ attainment status in 2010 base case:

- **Existing programs will bring 45 eastern counties (home to approximately 10 million people) into attainment with the fine particle standard (compared to current conditions).**

$PM_{2.5}$ attainment status in 2010 Clear Skies case:

- **Clear Skies would bring 42 additional eastern counties (home to approximately 14 million people) into attainment with the fine particle standard (as compared to the Base Case).**

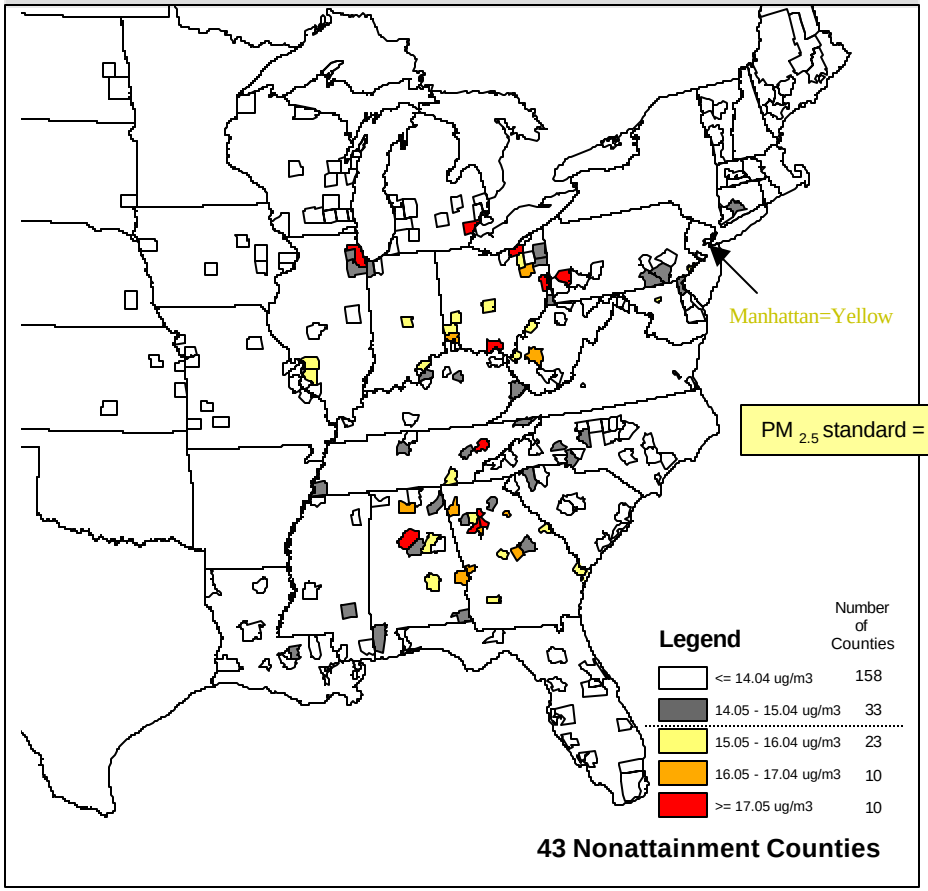
Remaining Counties Projected to Exceed the Annual Fine Particle Standards with Clear Skies and the Base Case in 2010



Notes: Based on 1999-2001 data of counties with monitors that have three years of complete data. Additional federal and state programs must bring all counties into attainment by 2016 at the latest. Clear Skies is not expected to bring additional counties into attainment for 2020 in the West. Therefore, the western region is not presented here.

Clear Skies Would Bring More Areas into Attainment with the $PM_{2.5}$ Standard in 2020

Remaining Counties Projected to Exceed the Annual Fine Particle Standard under the Base Case in 2020



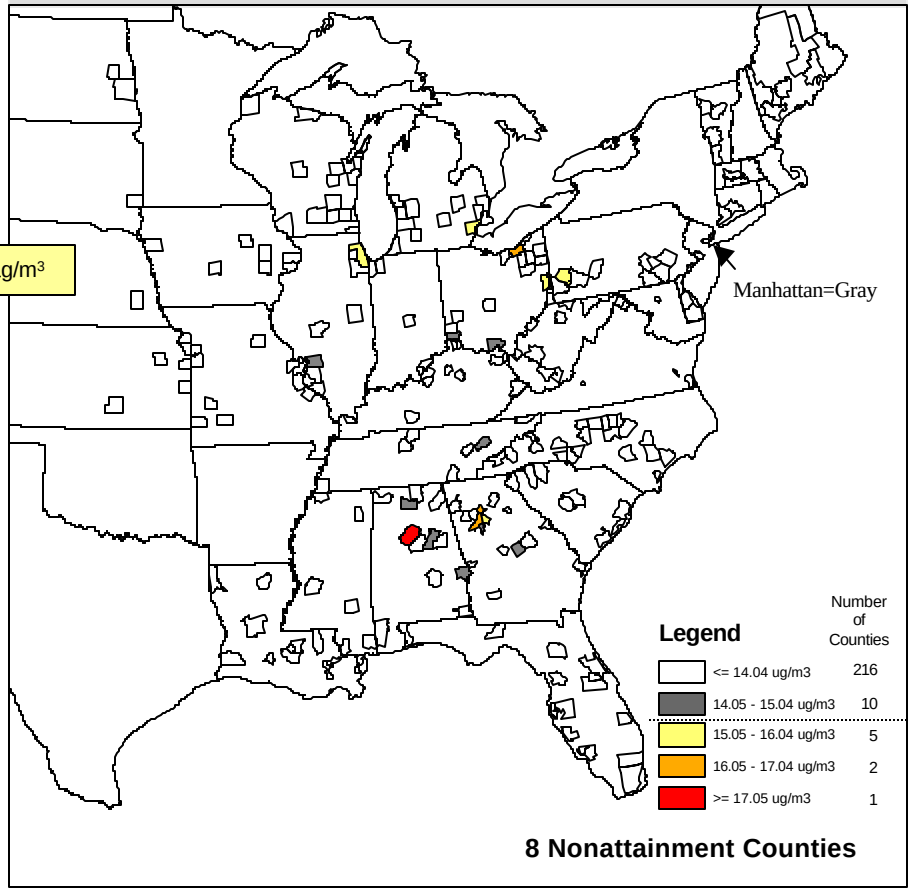
$PM_{2.5}$ attainment status in 2020 base case:

- **Existing programs will bring 71 eastern counties (home to approximately 18 million people) into attainment with the fine particle standard (compared to current conditions).**

$PM_{2.5}$ attainment status in 2020 Clear Skies Case:

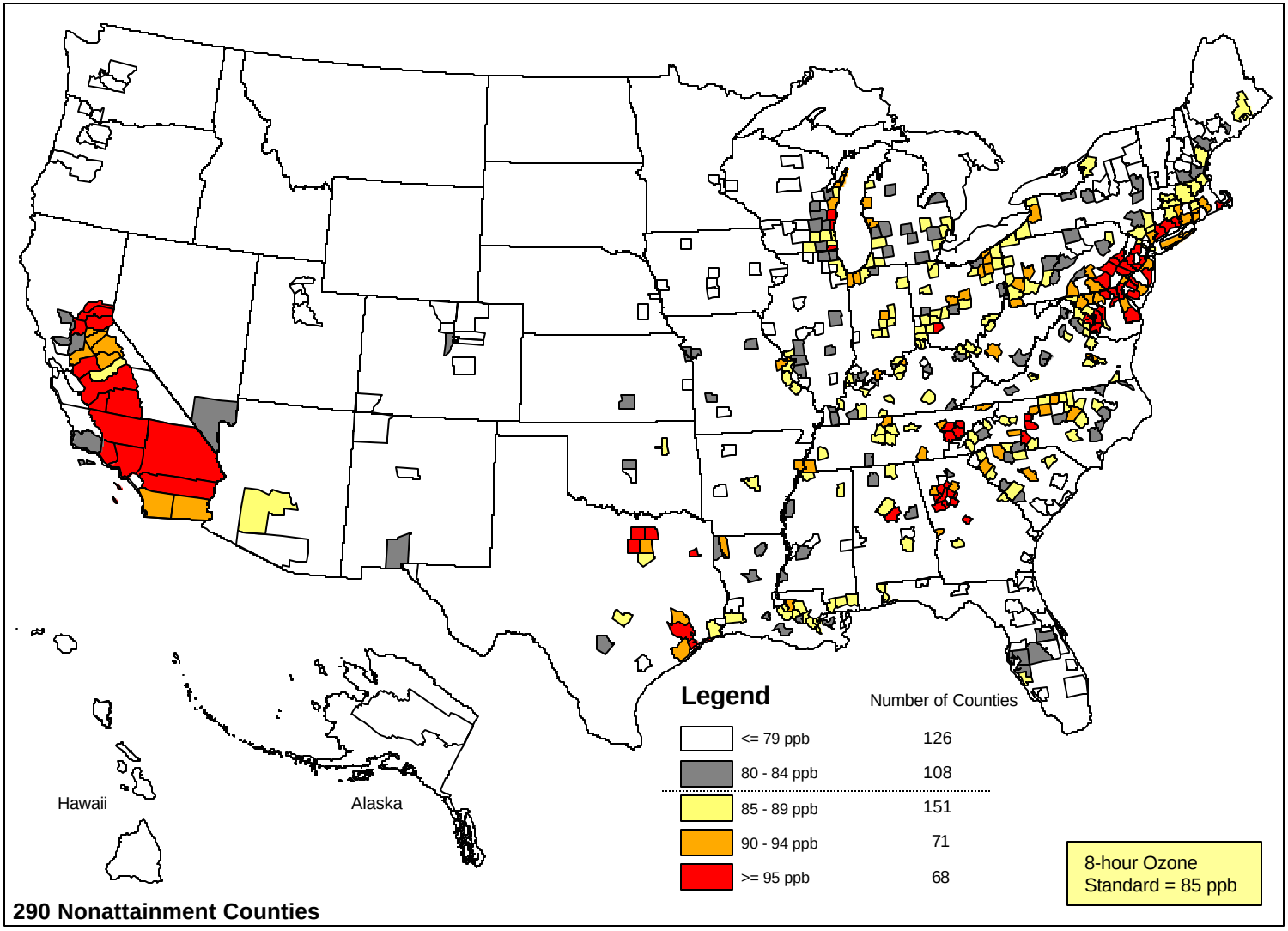
- **Clear Skies would bring 35 additional eastern counties (home to approximately 12 million people) into attainment with the fine particle standard (as compared to the Base Case).**

Remaining Counties Projected to Exceed the Annual Fine Particle Standard with Clear Skies and the Base Case in 2020



Notes: Based on 1999-2001 data of counties with monitors that have three years of complete data. Additional federal and state programs must bring all counties into attainment by 2016 at the latest. Clear Skies is not expected to bring additional counties into attainment for 2020 in the West. Therefore, the western region is not presented here.

Current Ozone Air Quality

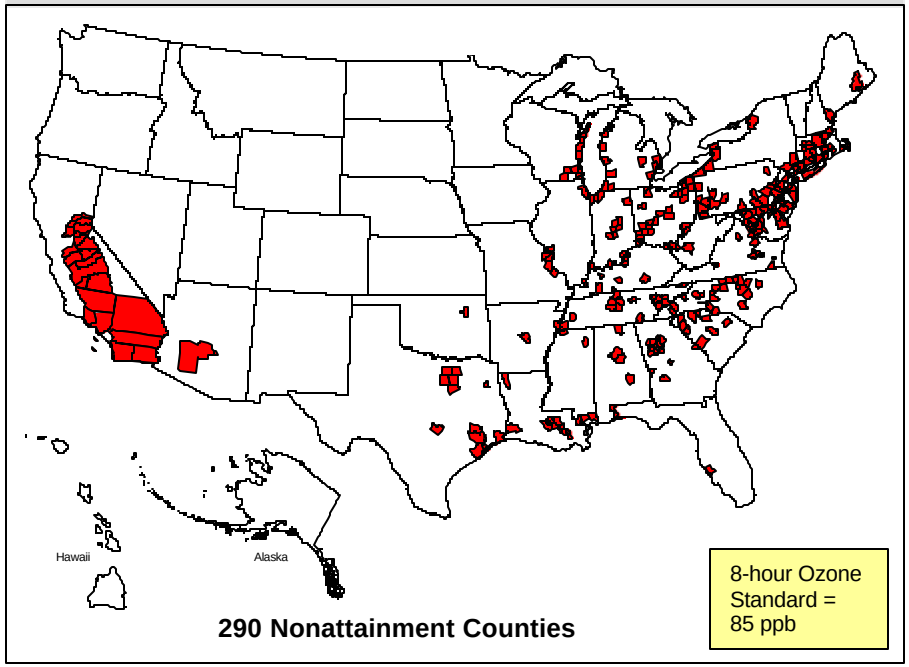


- **There are 290 counties nationwide (268 counties in the East) that exceed the 8-hour ozone standard.**
- **111 million people (87 million people in the East) live in counties that would not meet this standard.**

Note: Based on 1999-2001 monitoring data of counties with monitors that have three years of complete data.

Clear Skies with Other Air Programs Would Substantially Improve Ozone Attainment over the Next Two Decades

Counties Exceeding the 8-hour Ozone Standard in 2001



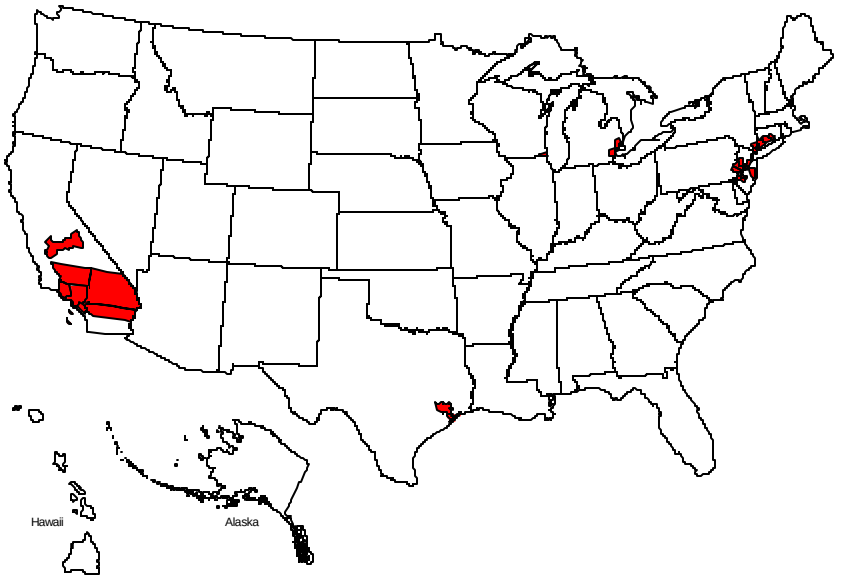
290 Nonattainment Counties

- **There are 290 counties nationwide (268 counties in the East) currently estimated to exceed the 8-hour ozone standard.**
  - **111 million people (87 million people in the East) currently live in counties with projected ozone concentrations greater than the 8-hour ozone standard of 85 ppb.**

Most counties would be brought into attainment with the ozone standard by 2020 :

- **Clear Skies and existing programs (primarily the NOx SIP Call and vehicle rules, including the proposed non-road rule) will bring 263 counties (home to approximately 77 million people) into attainment with the 8-hour ozone standard (compared to current conditions).**

Remaining Counties Projected to Exceed the 8-hour Ozone Standard with Clear Skies and the Base Case in 2020

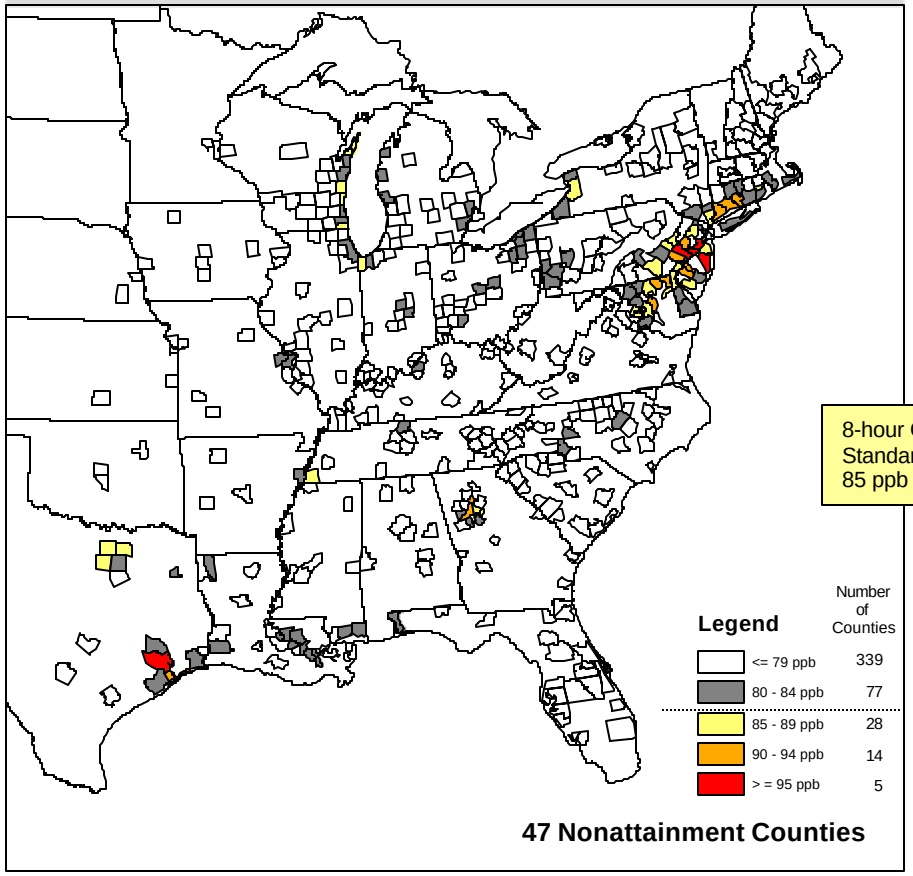


27 Nonattainment Counties

Notes: Based on 1999-2001 data of counties with monitors that have three years of complete data. Additional federal and state programs must bring all counties into attainment between 2007 and 2021. The methodology used to predict nonattainment status in the West is different than that used for the East.

Clear Skies Achieves Early Benefits by Bringing More Areas into Attainment with the 8-hour Ozone Standard in 2010

Remaining Counties Projected to Exceed the 8-hour Ozone Standard under Base Case in 2010



Ozone attainment status in 2010 base case:

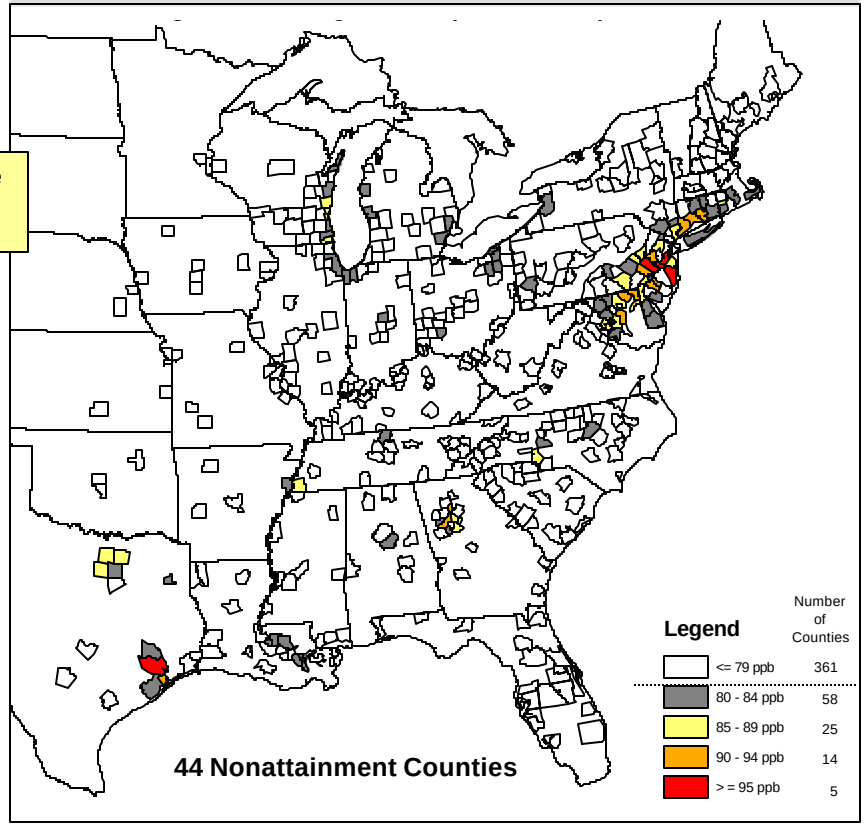
- **Existing programs (primarily the NOx SIP Call and vehicle rules) will bring 221 additional eastern counties (home to approximately 61 million people) into attainment with the 8-hour ozone standard (compared to current conditions).**

Ozone attainment status in 2010 Clear Skies case:

- **The NOx SIP Call will bring many Eastern counties into attainment with the 8-hour ozone standard.**
- **With Clear Skies, as compared to the Base Case, the number of counties out of attainment with the 8-hour ozone standard decreases from 47 to 44 (approximately 1 million more people living in counties in attainment).**

8-hour Ozone Standard = 85 ppb

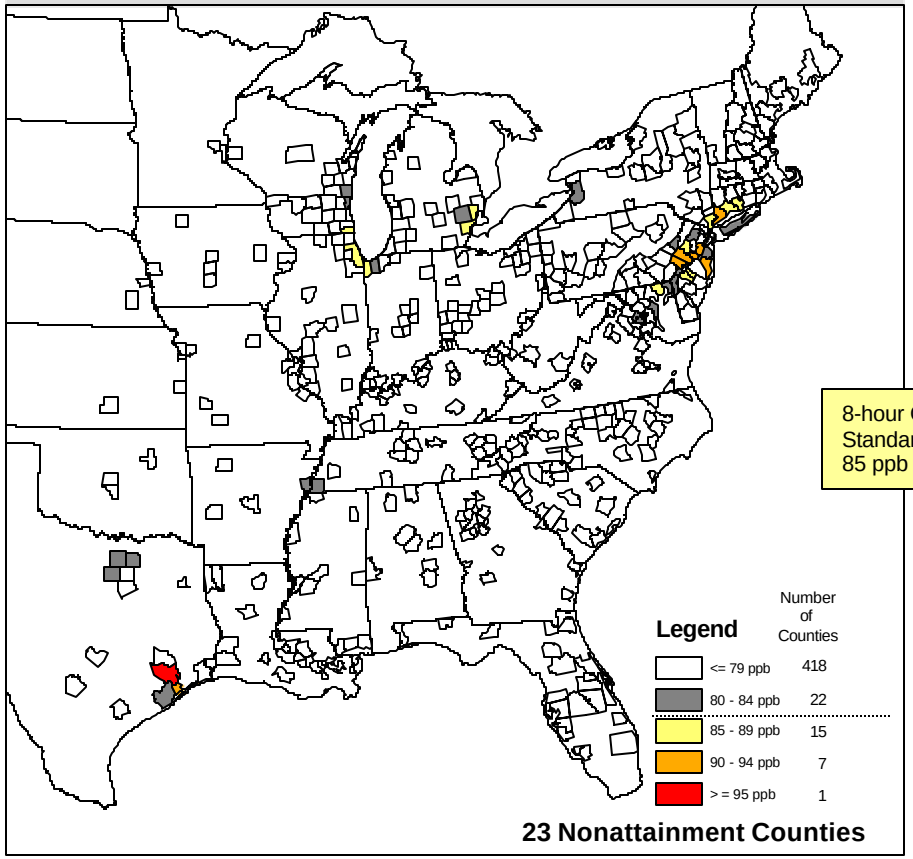
Remaining Counties Projected to Exceed the 8-hour Ozone Standard with Clear Skies and the Base Case in 2010



Notes: Based on 1999-2001 data of counties with monitors that have three years of complete data. Additional federal and state programs must bring all counties into attainment between 2007 and 2021. Clear Skies is not expected to bring additional counties into attainment for 2010 in the West. Therefore, the western region is not presented here.

Clear Skies Would Bring More Areas into Attainment with the 8-hour Ozone Standard in 2020

Remaining Counties Projected to Exceed the 8-hour Ozone Standard under Base Case in 2020



Ozone attainment status in 2020 base case:

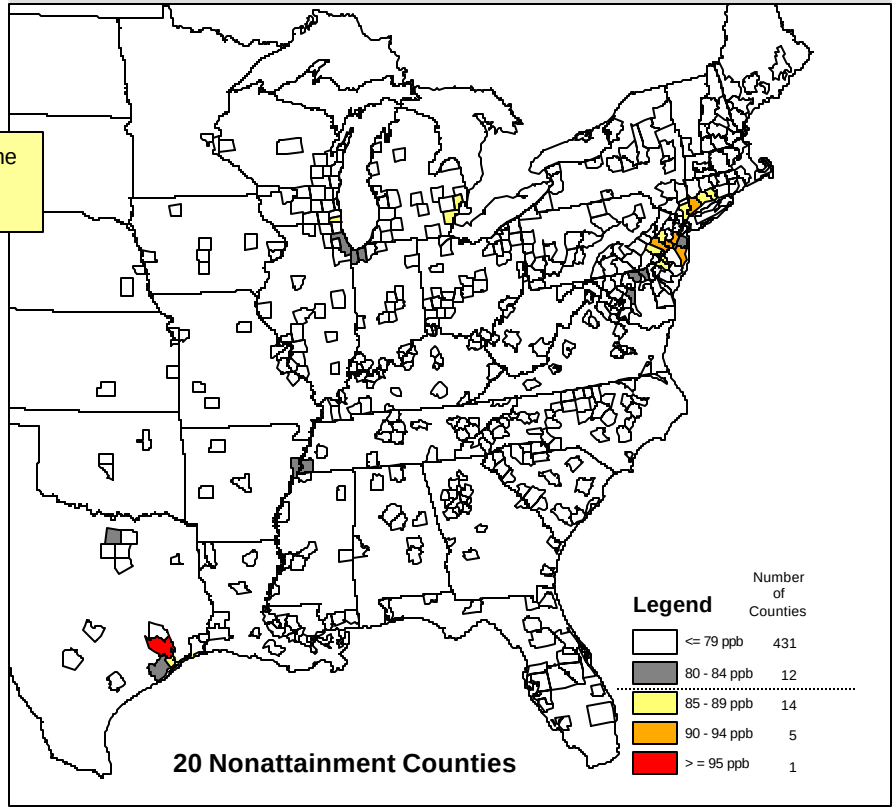
- **Existing programs (primarily the NOx SIP Call and vehicle rules, including the proposed non-road rule) will bring 245 eastern counties (home to approximately 65 million people) into attainment with the 8-hour ozone standard (compared to current conditions).**

Ozone attainment status in 2020 Clear Skies case:

- **The NOx SIP Call will bring many Eastern counties into attainment with the 8-hour ozone standard.**
- **Clear Skies would bring 3 additional counties (home to approximately 6 million people) into attainment with the 8-hour ozone standard (as compared to the Base Case).**

Remaining Counties Projected to Exceed the 8-hour Ozone Standard with Clear Skies and the Base Case in 2020

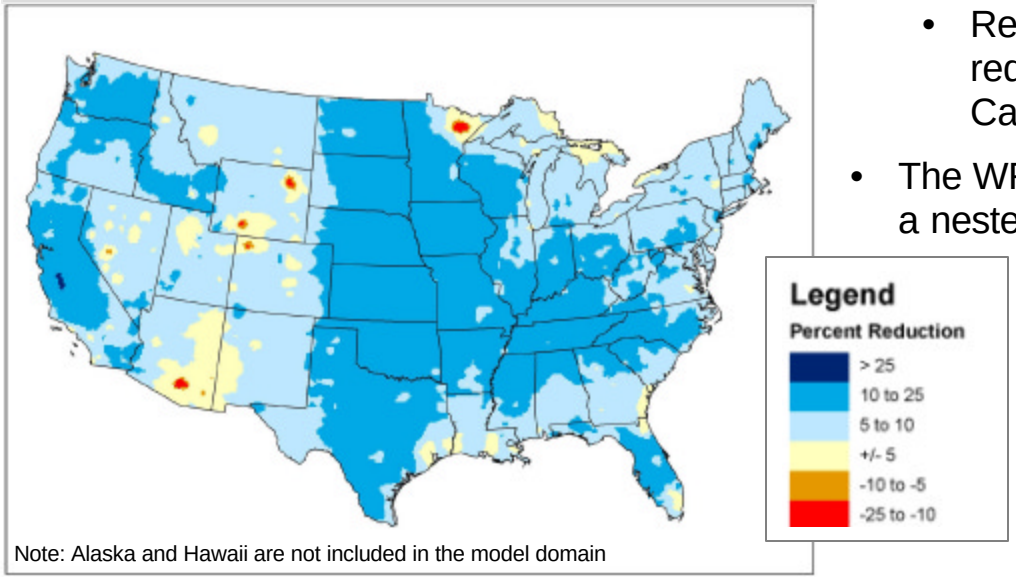
8-hour Ozone Standard = 85 ppb



Notes: Based on 1999-2001 data of counties with monitors that have three years of complete data. Additional federal and state programs must bring all counties into attainment between 2007 and 2021. Clear Skies is not expected to bring additional counties into attainment for 2020 in the West. Therefore, the western region is not presented here.

Fine Particle Improvements in 2020

Projected Changes in Fine Particles with the Base Case in 2020 Compared to 2001

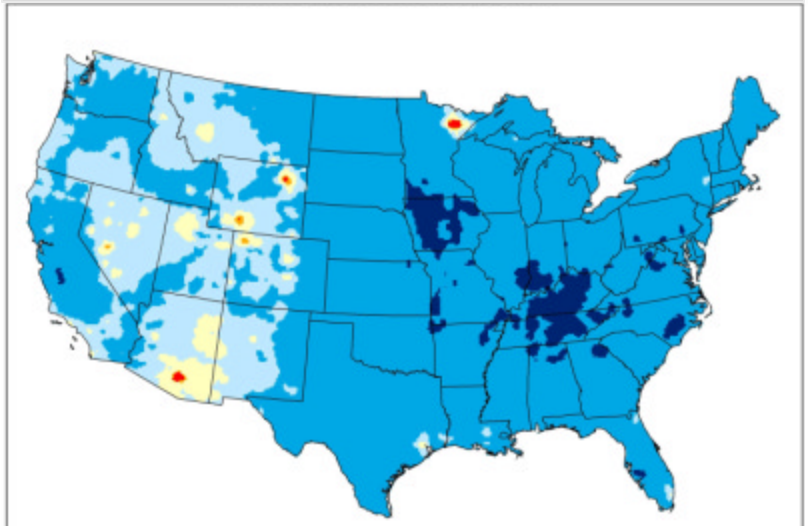


Note: Alaska and Hawaii are not included in the model domain

- The top map demonstrates the effects of existing programs (Base Case) in comparison to current concentrations.
  - Reductions in the Eastern Plains and West are due to reductions in mobile source emissions in the Base Case (e.g. nonroad diesel vehicles).
- The WRAP emission reductions are part of Clear Skies as a nested program.

- The bottom map demonstrates the effects of Clear Skies in combination with the Base Case in comparison to current concentrations.
  - Fine particle concentrations in a large portion of the East and Midwest would improve up to 25% from current levels.
  - Additional significant decreases of greater than 25% are expected throughout the Ohio River Valley and into the Southeast and mid-Atlantic due to reductions in emissions from power generation.

Projected Changes in Fine Particles with Clear Skies and the Base Case in 2020 Compared to 2001

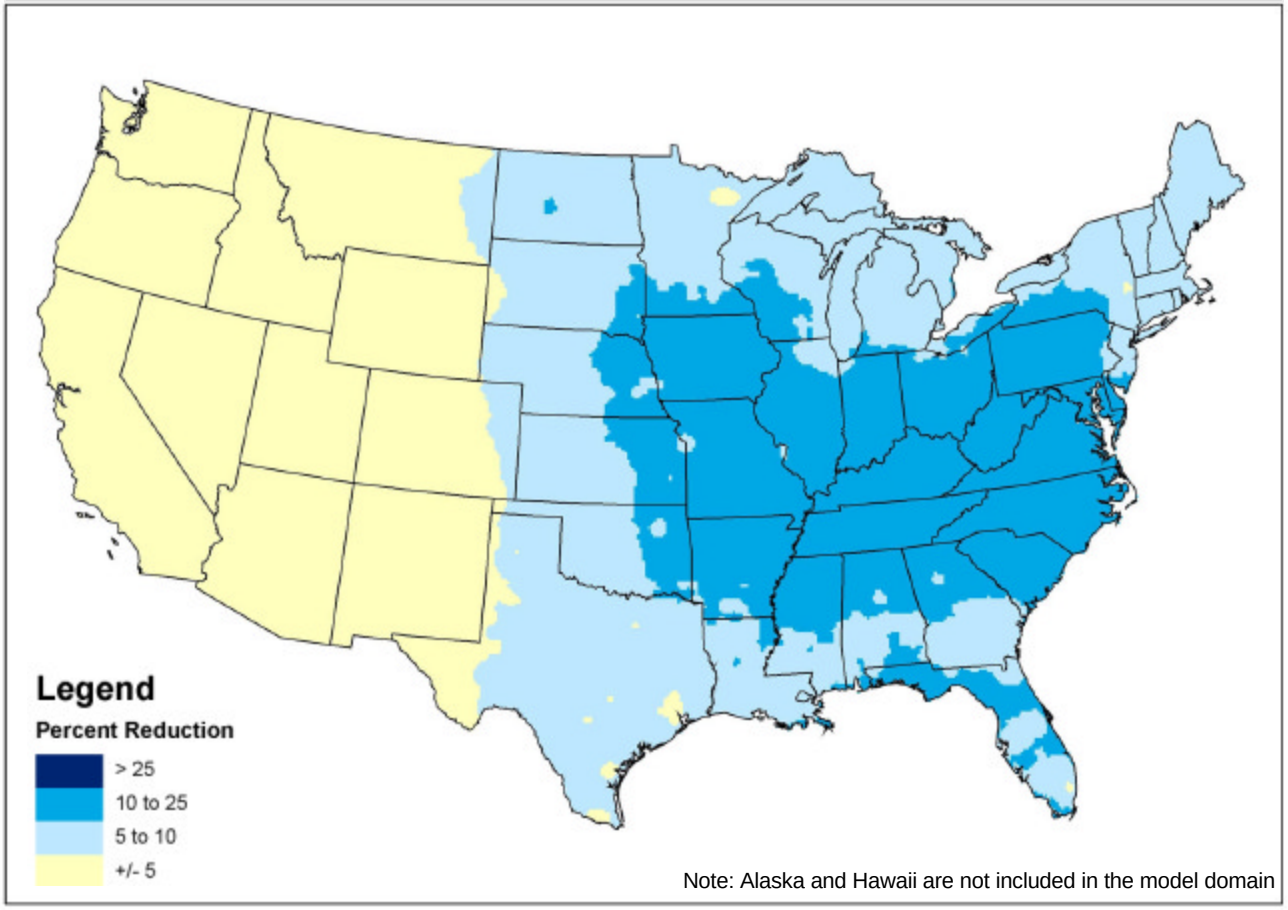


Note: Alaska and Hawaii are not included in the model domain

Note: The increases in fine particle concentrations in Minnesota, Arizona, Wyoming, and in the intermountain West occur under both the Base Case and Clear Skies and are the result of increases in emissions from metal smelting, mining, and other sources not affected by Clear Skies.

Clear Skies Fine Particle Improvements in 2020

Projected Changes in Fine Particles with Clear Skies Compared to the Base Case in 2020

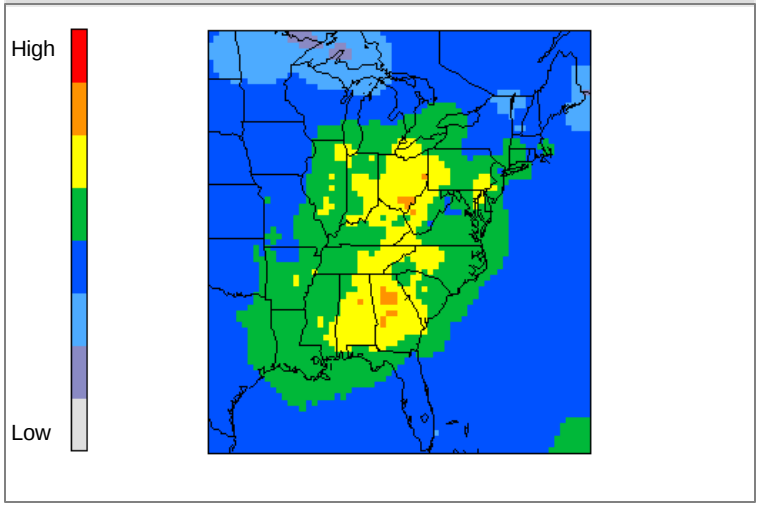


- Currently, SO_2 and NOx emissions account for a substantial fraction of fine particle concentrations, particularly in the East.
- The Clear Skies SO_2 and NOx emission reductions would reduce fine particle concentrations in much of the East and Midwest 10-25% beyond what is expected under the Base Case.

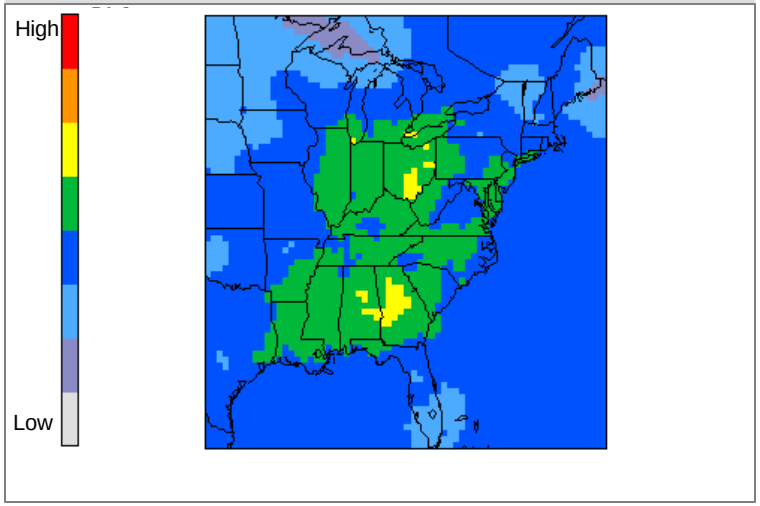
Human Health Benefits of Reducing Fine Particles and Ozone in 2020

- **Reductions in fine particles and ozone[1] under Clear Skies would improve public health. By 2020, Americans would annually experience approximately:**
  - 14,100 fewer premature deaths;
    - An alternative estimate projects 8,400 fewer premature deaths.[2]
  - 8,800 fewer cases of chronic bronchitis;
  - 23,000 fewer non-fatal heart attacks;
  - 30,000 fewer hospitalizations/emergency room visits for cardiovascular and respiratory symptoms;
    - Included in this total are 15,000 fewer hospital and emergency room visits for asthma.
  - 12.5 million fewer days with respiratory illnesses and symptoms, including work loss days, restricted activity days, and school absences.
    - Included in this total are hundreds of thousands fewer respiratory symptoms and illnesses for asthmatics, including approximately 180,000 fewer asthma attacks.
- **The monetized health benefits of the Clear Skies Act would total approximately $110 billion annually in 2020.**
  - An alternative estimate projects annual health benefits of $21 billion.[2]

Fine Particle Concentrations in 2020 (Base Case)



Fine Particle Concentration in 2020 (Clear Skies)



[1,2] See page B49 for notes on the health and visibility benefits analysis

Early Human Health Benefits of Clear Skies in 2010

- The Clear Skies Act would result in substantial **early** human health and visibility benefits due to reductions in fine particles and ozone.[1]

- **By 2010, Americans would annually experience approximately:**
  - 7,900 fewer premature deaths;
    - An alternative estimate projects 4,700 fewer premature deaths;[2]
  - 5,400 fewer cases of chronic bronchitis;
  - 13,100 fewer non-fatal heart attacks;
  - 16,900 fewer hospitalizations/emergency room visits for cardiovascular and respiratory symptoms;
    - Included in this total are 9,000 fewer hospital and emergency room visits for asthma.
  - 8 million fewer days with respiratory illnesses and symptoms, including work loss days, restricted activity days, and school absences.
    - Included in this total are hundreds of thousands fewer respiratory symptoms and illnesses for asthmatics, including over 70,000 fewer asthma attacks.

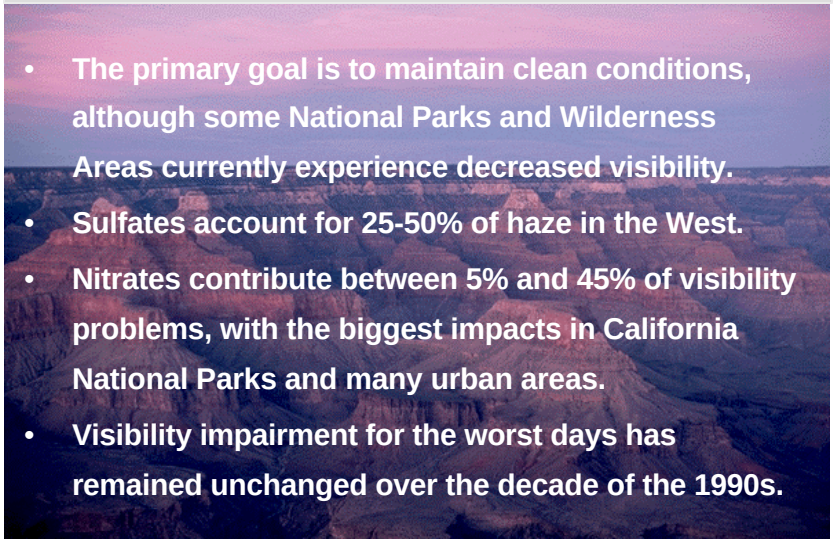
- The monetized health benefits of the Clear Skies Act would total approximately $54 billion annually in 2010.
  - An alternative estimate projects annual health benefits of $10 billion.[2]

[1,2] See page B49 for notes on the health and visibility benefits analysis

Fine Particles in the Air Decrease Visibility

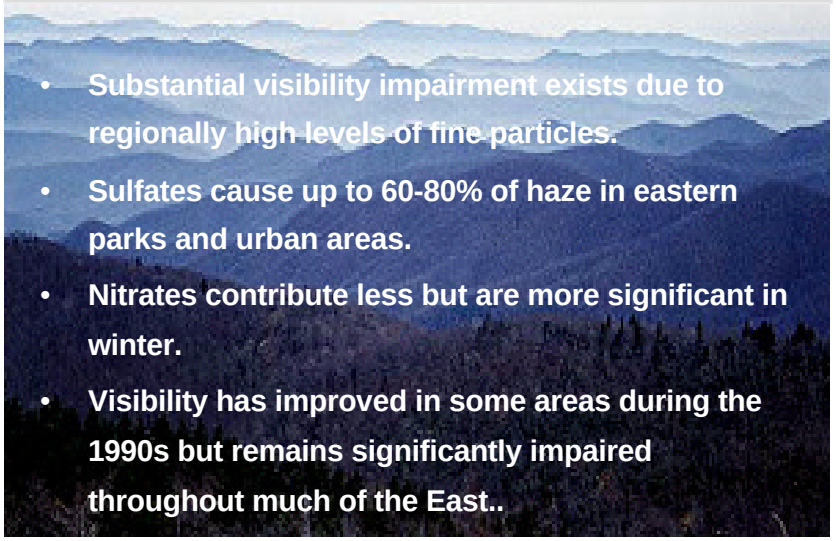
- SO_2 and NOx emissions form sulfate and nitrate particles in the atmosphere that can be transported many miles downwind from emissions sources.
- These fine particles in the air scatter light and create hazy conditions, decreasing visibility. Decreased visibility is sometimes known as “regional haze.” Humidity intensifies the visibility degradation caused by fine particles, particularly in the East.
- Effects of visibility impairment include:
  - Spoiled scenic vistas across broad regions of the country, including those in many National Parks and Wilderness Areas;
  - Reduced visual range to 10 miles or less (as much as 80%) on the haziest days in some National Parks;
  - Impaired urban vistas nationwide.

In the West:



- **The primary goal is to maintain clean conditions, although some National Parks and Wilderness Areas currently experience decreased visibility.**
- **Sulfates account for 25-50% of haze in the West.**
- **Nitrates contribute between 5% and 45% of visibility problems, with the biggest impacts in California National Parks and many urban areas.**
- **Visibility impairment for the worst days has remained unchanged over the decade of the 1990s.**

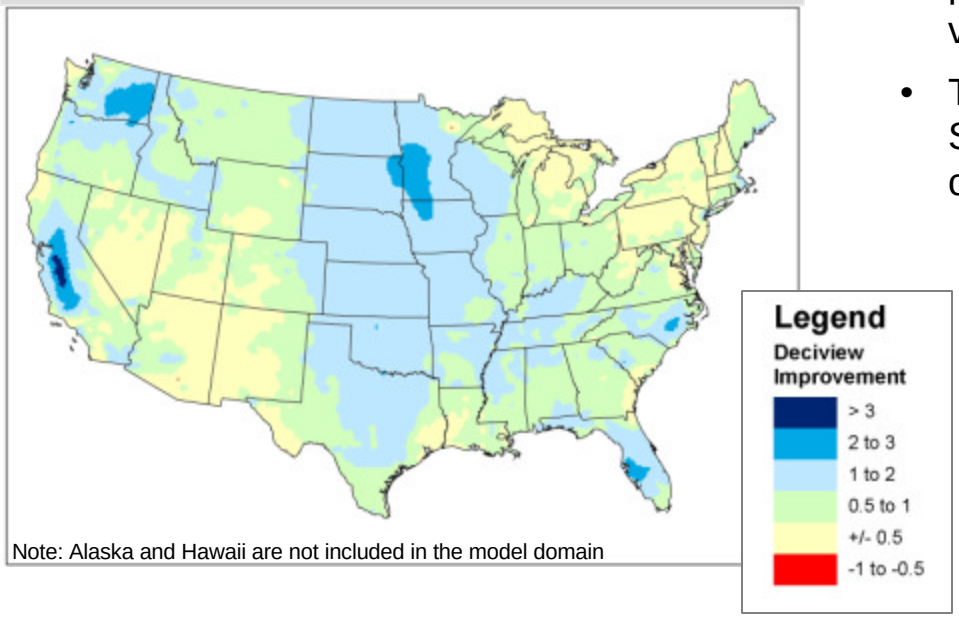
In the East:



- **Substantial visibility impairment exists due to regionally high levels of fine particles.**
- **Sulfates cause up to 60-80% of haze in eastern parks and urban areas.**
- **Nitrates contribute less but are more significant in winter.**
- **Visibility has improved in some areas during the 1990s but remains significantly impaired throughout much of the East..**

Visibility Improvements in 2020

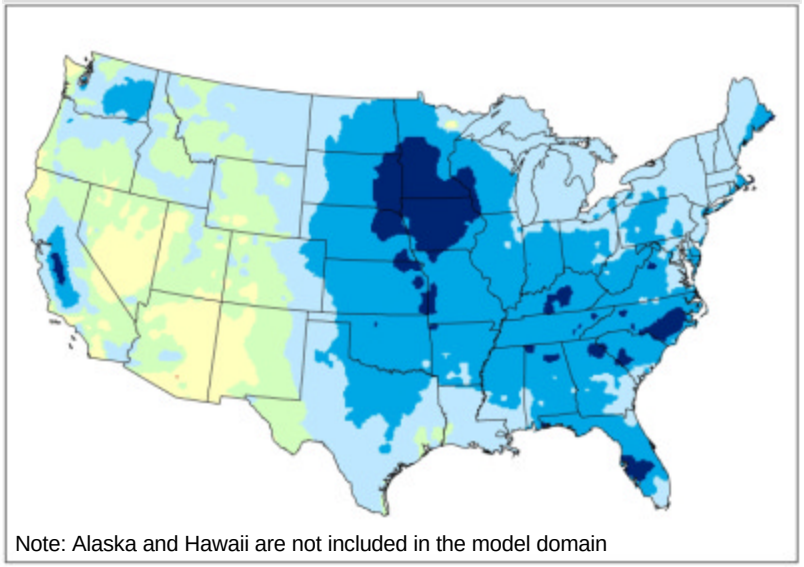
Projected Changes in Visibility with the Base Case in 2020 Compared to 2001



Note: Alaska and Hawaii are not included in the model domain

- The top map demonstrates the effect of existing programs (Base Case) in comparison to current visibility levels.
- The bottom map demonstrates the effect of Clear Skies in combination with the Base Case in comparison to current visibility levels.

Projected Changes in Visibility with Clear Skies and the Base Case in 2020 Compared to 2001



Note: Alaska and Hawaii are not included in the model domain

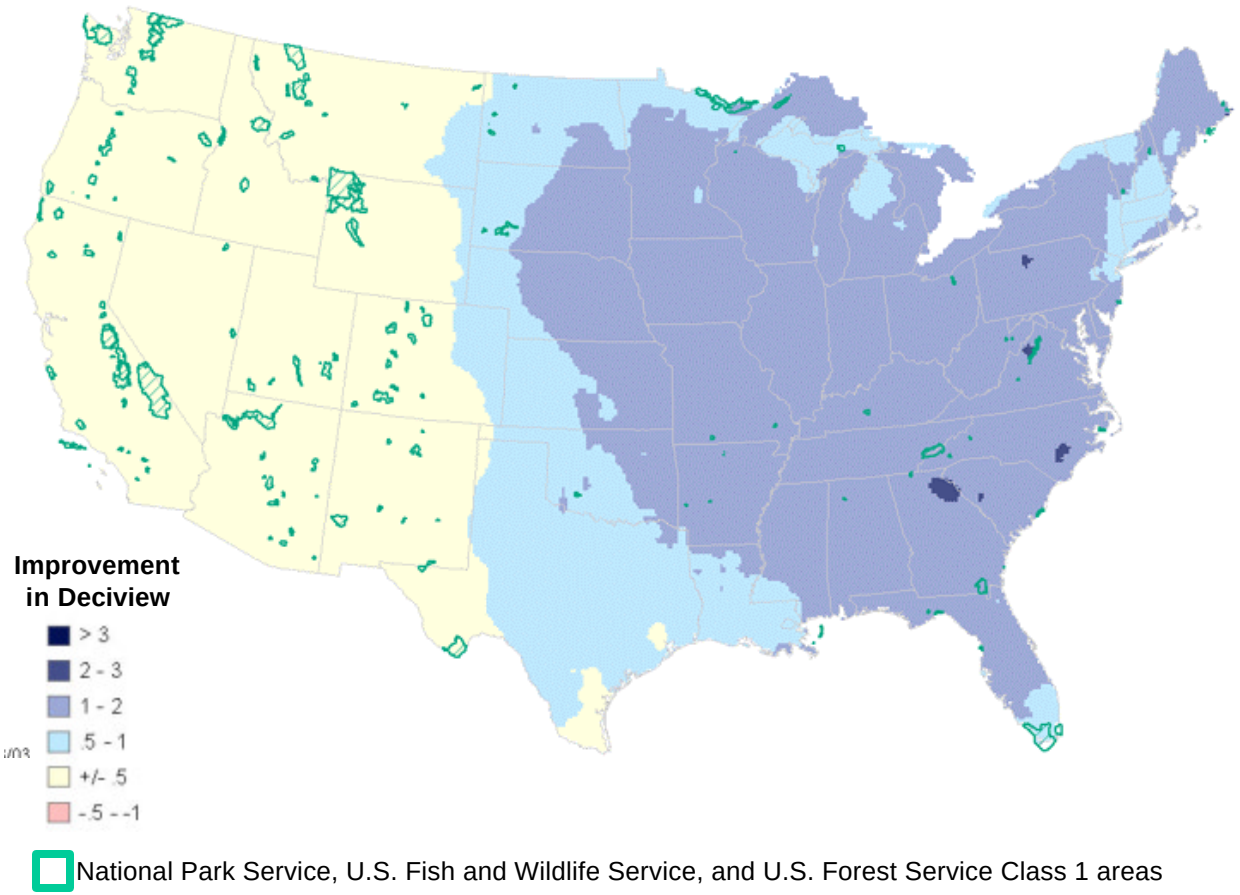
- As the lower map shows, Clear Skies in combination with the Base Case, including the proposed Nonroad Diesel rule, would improve visibility in a large portion of the East and Midwest 2-3 deciviews* from current levels.
  - Visibility in portions of the Southeast and the eastern Plains/Upper Midwest would improve more than 3 deciviews*.

Note: Neither the Base Case or Clear Skies modeling fully incorporates the additional emission reductions expected from implementation of the WRAP.

*A deciview is a measure of visibility which captures the relationship between air pollution and human perception of visibility. When air is free of the particles that cause visibility degradation, the Deciview Haze Index is zero. The higher the deciview level, the poorer the visibility; a one deciview change translates to a just noticeable change in visibility for most individuals.

Clear Skies Visibility Improvements in 2020

Projected Changes in Visibility with Clear Skies Compared to the Base Case in 2020



Note: Alaska and Hawaii are not included in the model domain

- Clear Skies would improve visibility over much of the Eastern U.S. 1-2 deciviews beyond what is expected under the Base Case (a change of 1-2 deciviews is perceptible).
  - In the southeastern U.S., this translates into an improvement in visual range of approximately 2-4 miles.
- Under Clear Skies, the Western Regional Air Partnership agreement would be honored and the emissions reductions are projected to take effect.
  - This will allow future growth in the West to occur without degrading visibility.

Note: Neither the Base Case or Clear Skies modeling fully incorporates the additional emission reductions expected from implementation of the WRAP.

Some Visibility Benefits Can Be Monetized

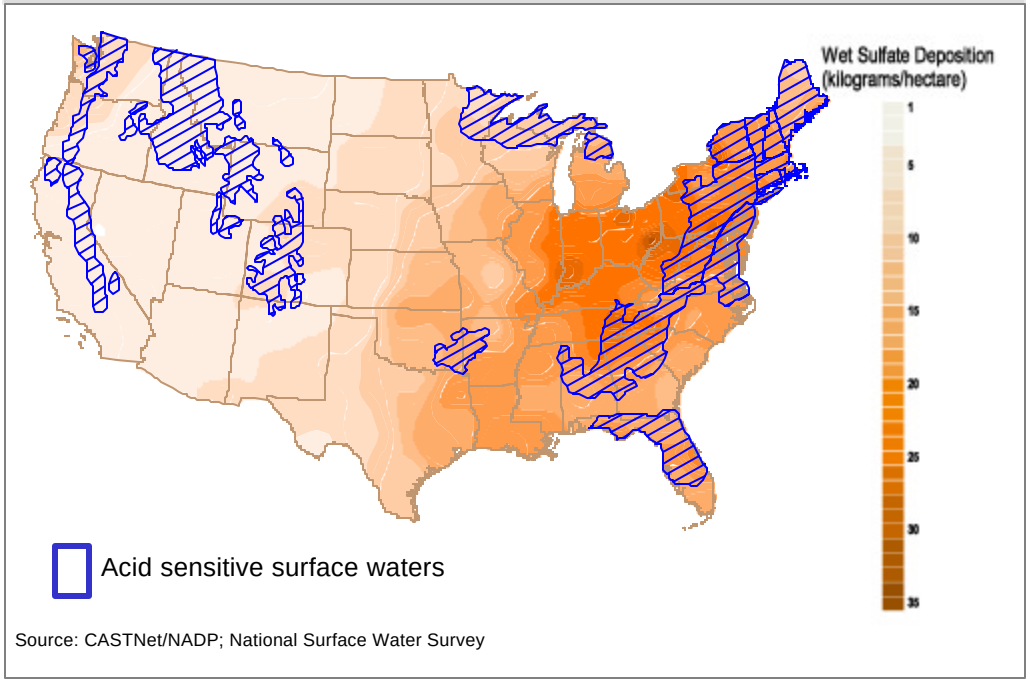
- This assessment projects benefits due to improvements in impaired visibility in National Parks and Wilderness areas in many Class I areas in the Southeast (including Shenandoah and Great Smoky Mountain National Parks, two of the most heavily visited National Parks), the Southwest, and California.
- For these areas, Clear Skies would achieve approximately:
  - $1 billion in annual visibility benefits by 2010;
  - $3 billion in annual visibility benefits by 2020.
- This estimate does not include the value of improving visibility in residential areas. It also does not include the value of improving visibility at National Parks and Wilderness Areas in other areas of the country (such as the Northeast) that would be improved by Clear Skies.[3]

[3] See page B49 for notes on the health and visibility benefits analysis

Acid Rain Damages Lakes, Streams, Forests, and Buildings

- Acid deposition occurs when emissions of SO_2 and NOx react in the atmosphere to create acidic gases and particles which reach the Earth in wet and dry forms.
- The greatest sulfur and nitrogen deposition occurs in areas of the Midwest and northeastern United States which are downwind of the highest SO_2 and NOx emission areas.
- Impacts occur in both the eastern U.S. and mountainous areas of the West.
- Effects of acid deposition include:
  - Acidification of lakes and streams, making them unable to support fish and other aquatic life;
  - Damage to forests through acidification of soil, depletion of soil nutrients, and direct injury to sensitive tree leaves and needles;
  - Harm to buildings, statues and monuments.

Wet Sulfate Deposition (1997-1999) and Acid-Sensitive Surface Waters

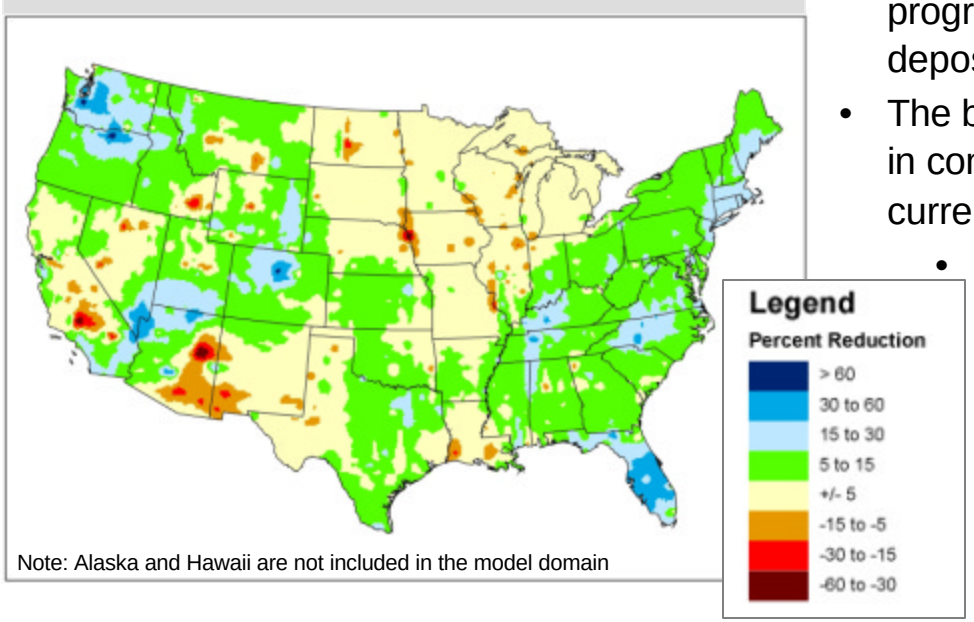


Source: CASTNet/NADP; National Surface Water Survey

- Despite substantial emissions reductions over the last 20 years, high levels of sulfur and nitrogen deposition still enter acid-sensitive lakes and streams, leading to high levels of acidity.
- Southeastern streams would continue to grow **more** acidic without significant further reductions in sulfate and nitrogen deposition.
- Many scientists believe that significant further reductions in SO_2 and NOx emissions are necessary to fully protect acid-sensitive ecosystems.

Sulfur Deposition Improvements in 2020

Projected Changes in Sulfur Deposition with the Base Case in 2020 Compared to 2001

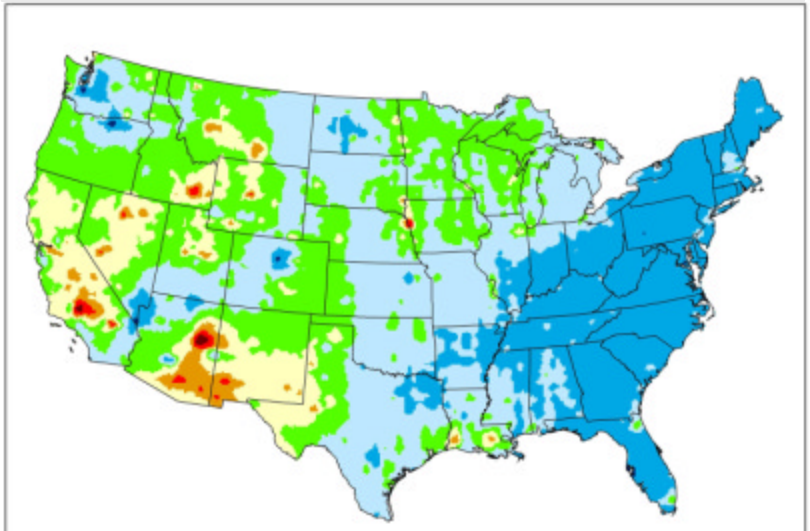


Note: Alaska and Hawaii are not included in the model domain

- The top map demonstrates the effect of existing programs (Base Case) in comparison to current deposition levels.
- The bottom map demonstrates the effects of Clear Skies in combination with the Base Case in comparison to current deposition levels.
  - Clear Skies, in combination with the Base Case, would reduce sulfur deposition up to 60% from current levels throughout much of the Eastern U.S.

- Sulfur deposition in the West is generally low, so the large percentage increases correspond to relatively small changes in actual deposition (less than 1 kg/ha). These increases come from expected increases in emissions primarily from sources not affected by Clear Skies (e.g., metals processing, petroleum refining, chemical and fertilizer manufacturing). A few power plants are expected to increase emissions slightly under existing programs.

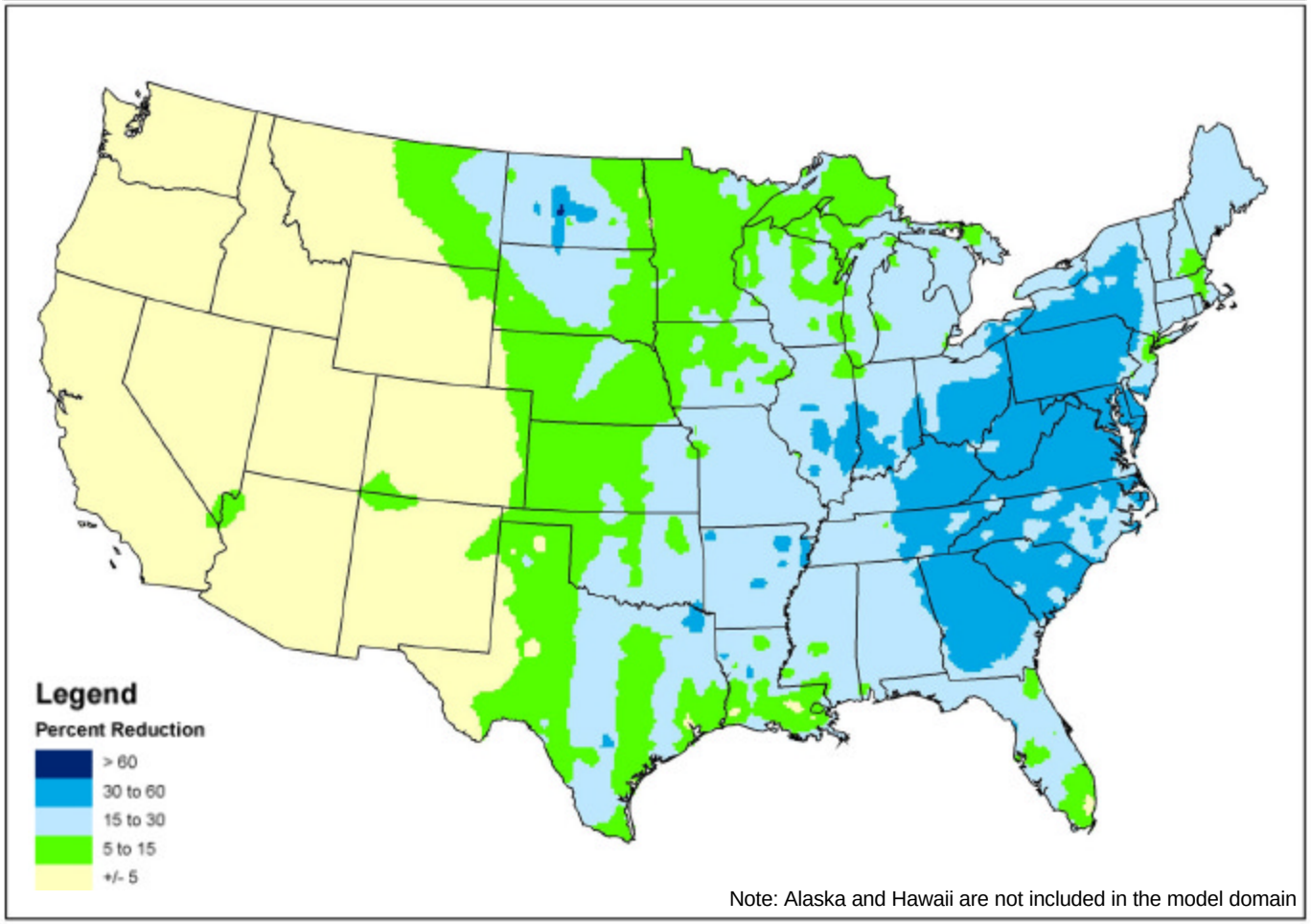
Projected Changes in Sulfur Deposition with Clear Skies and the Base Case in 2020 Compared to 2001



Note: Alaska and Hawaii are not included in the model domain

Clear Skies Sulfur Deposition Improvements in 2020

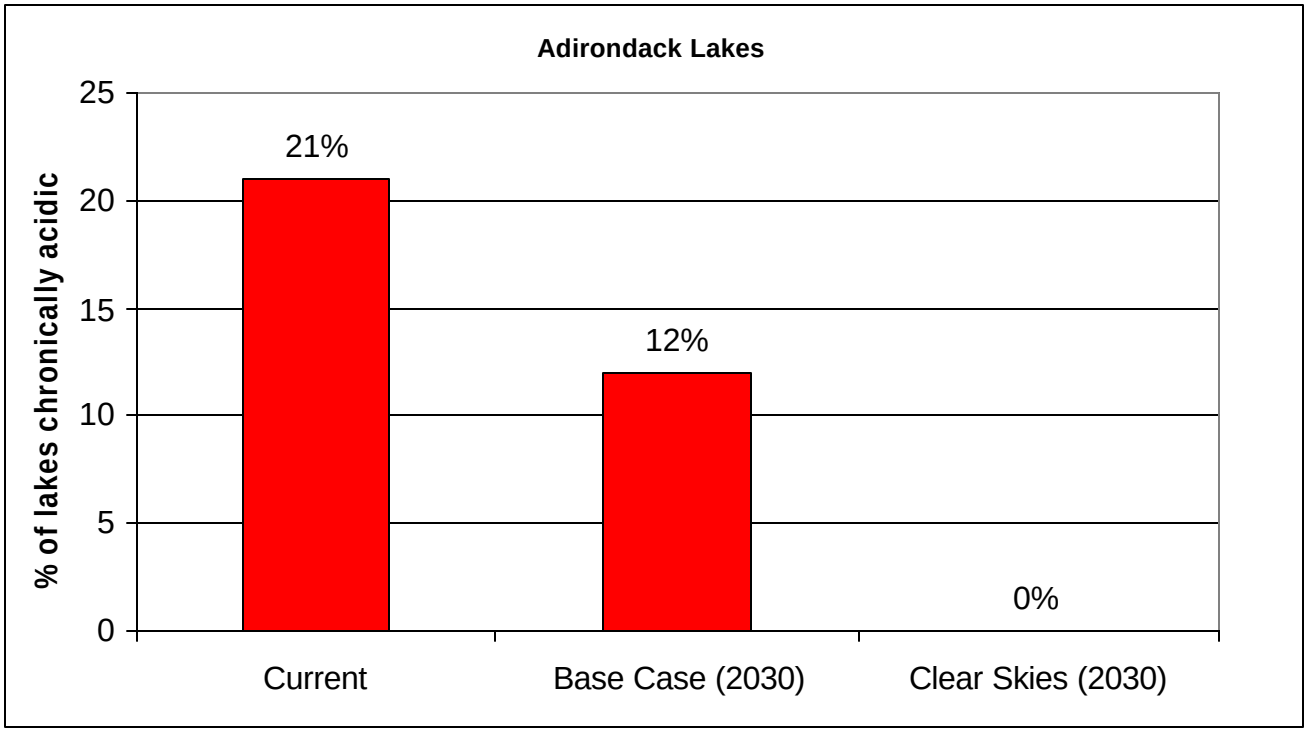
Projected Changes in Sulfur Deposition with Clear Skies Compared to the Base Case in 2020



- Clear Skies would achieve significant additional reductions in sulfur deposition of up to 60% beyond what is expected under the Base Case in 2020.
- The greatest reductions of 30-60% would center on the Appalachian Mountains from northern New York state to the southern Blue Ridge and across broad regions of the southeastern U.S., including sensitive resources such as the Adirondack and Catskill Mountains

Reduced Acidity of Adirondack Lakes

- Lakes in the Adirondack Mountains generally respond rapidly to changes in emissions and deposition: larger decreases in deposition lead to significant reductions in acidity.
- Under the Base Case, lake conditions improve, but 12% of lakes would remain chronically acidic in 2030.[1]
- Clear Skies would eliminate chronic acidity from lakes in the Adirondacks.[2]
- However, a significant proportion of Adirondack lakes would still become acidic periodically due to seasonal or storm events.



[1] This may be an overestimate of recovery due to the fact that this modeling focuses only on sulfur deposition.

[2] Some Adirondack lakes are acidic due to natural causes (e.g. dissolved organic carbon).

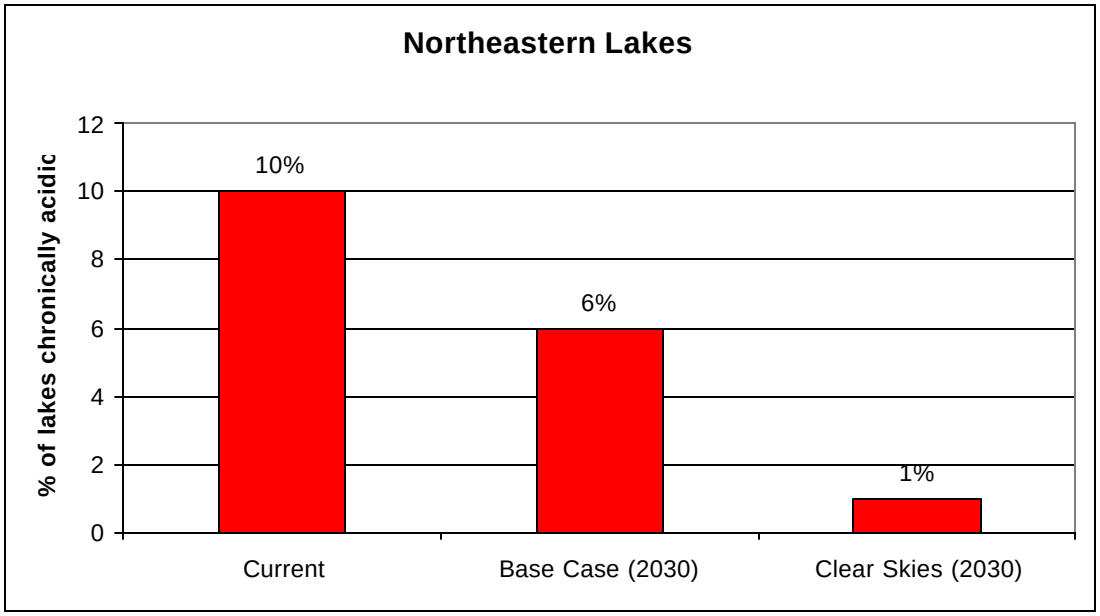
Reduced Acidity of Northeastern Lakes and Southeastern Streams

Northeast Region

- Lakes in the Northeast region (including Adirondack lakes) are both “direct” and “delayed response” systems; some lakes may not completely respond by 2030 to the deposition changes considered here.
- Under the Base Case, lake condition improves slightly in the Northeast by 2030, but 6% of lakes remain chronically acidic.
- With the Clear Skies Act, chronic acidity would be virtually eliminated by 2030.*
- However, some lakes would still become acidic periodically due to seasonal or storm events.

Southeast Region

- Large reductions in emissions and deposition, such as those implemented under Clear Skies, are necessary simply to slow the long-term decline in stream condition in the Southeast.
- Under the Base Case, stream condition worsens.
- Under Clear Skies, the rate of stream acidification would slow.



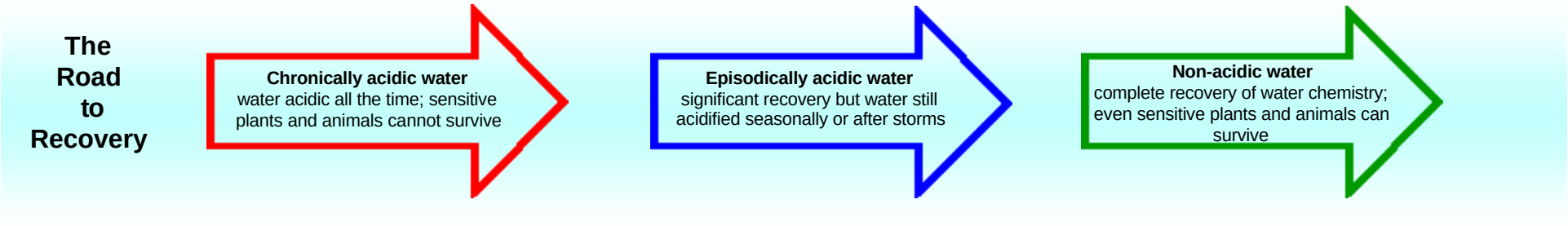
***Note**: This may be an overestimate of recovery under existing programs due to the fact that this modeling focuses only on sulfur deposition.

Summary of Improvements Due to Reductions in Acid Deposition

	Northeastern Lakes	Current	Base Case (2030)	Clear Skies (2030)
	chronically acidic	10%	6%	1%
	episodically acidic	21%	25%	28%
	non-acidic	69%	69%	71%
	Adirondack Lakes			
	chronically acidic	21%	12%	0%
	episodically acidic	43%	52%	64%
	non-acidic	36%	36%	36%
	Southeastern Streams			
	chronically acidic	17%	17%	17%
	episodically acidic	19%	25%	23%
	non-acidic	64%	58%	60%

This table shows the percentage of waterbodies in regions of the Eastern U.S. that are chronically, episodically, and non-acidic under Clear Skies as compared to current conditions and the Base Case.

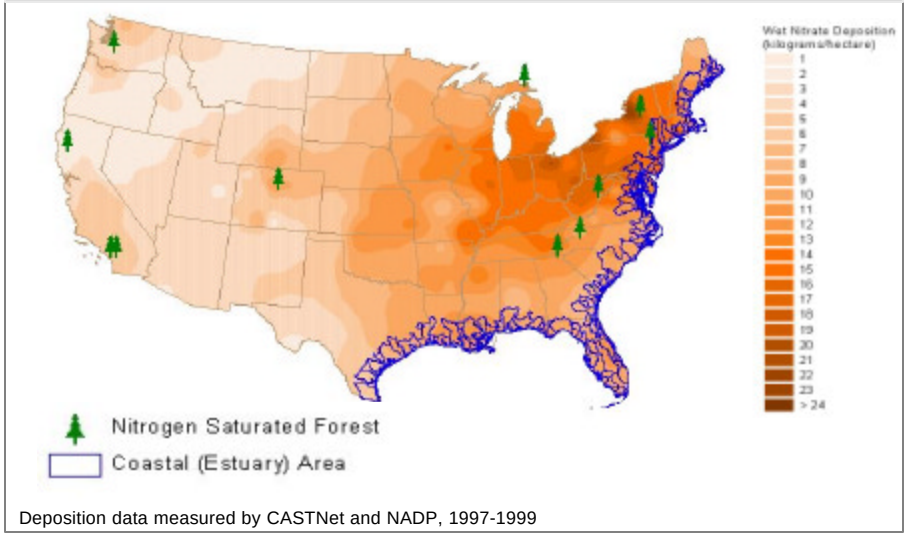
- A key indicator of the health of acid-sensitive lakes and streams is their ability to buffer or neutralize acid deposition. This capacity is measured as acid neutralizing capacity (ANC).
- Chronically acidic waters have low ANC (less than 0). As ANC increases and the recovery process begins, waters first become episodically acidic (ANC of 0-50 µeq/l) and finally non-acidic (ANC > 50).
- In addition to reducing the number of chronically acidic lakes in the Northeast and Adirondacks, Clear Skies would improve the acid buffering capacity of lakes in those regions.
- In the Southeast, Clear Skies would slow the further deterioration of stream health expected under the Base Case.



Nitrogen Deposition Harms Forests and Coastal Ecosystems

- **NOx emissions from power plants contribute significant amounts of nitrogen to coastal waters and sensitive forests.**
  - For example, 10-40% of the nitrogen reaching East and Gulf coast estuaries is transported and deposited via the atmosphere.
- Excess nitrogen in coastal waters causes "eutrophication" and results in:
  - Algal blooms, some of which are toxic (e.g. red and brown tides);
  - Depletion of dissolved oxygen (hypoxia), stressing or killing marine life;
  - Loss of important habitat, such as seagrass beds and coral reefs;
  - Changes in marine biodiversity and species distribution;
  - Economic and social impacts due to loss of fisheries and tourism.
- Two thirds of U.S. estuaries (over 80) experience symptoms of moderate to high eutrophication.
- High nitrogen deposition levels can lead to loss of soil nutrients and damage sensitive forest ecosystems.
- Nitrogen saturation occurs when too much nitrogen enters sensitive forest soils and begins to leach out, stripping soil nutrients and impacting water quality.
- Signs of nitrogen saturation have been observed in various sensitive forests in the Eastern and Western U.S. (e.g., Great Smoky Mountains, Adirondack/Catskill Mountains, Colorado Front Range, southern California).

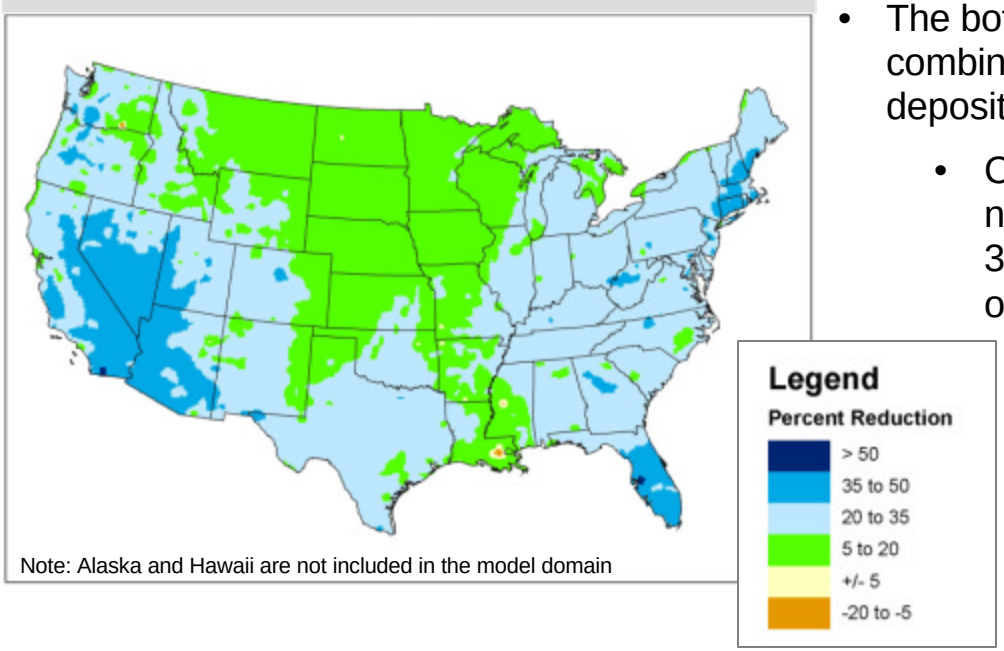
Annual Wet Nitrate Deposition to Sensitive Resources



Deposition data measured by CASTNet and NADP, 1997-1999

Nitrogen Deposition Improvements in 2020

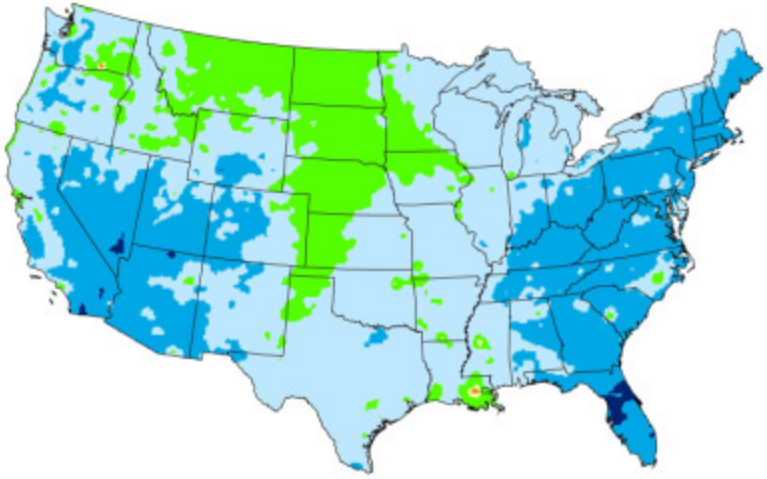
Projected Changes in Nitrogen Deposition with the Base Case in 2020 Compared to 2001



Note: Alaska and Hawaii are not included in the model domain

- The top map demonstrates the effect of existing programs (Base Case) in comparison to current deposition levels.
- The bottom map demonstrates the effect of Clear Skies in combination with the Base Case in comparison to current deposition levels.
  - Clear Skies and the Base Case together would reduce nitrogen deposition across much of the country up to 35%, with larger reductions of up to 50% across most of the East and large areas of the West.

Projected Changes in Nitrogen Deposition with Clear Skies and the Base Case in 2020 Compared to 2001



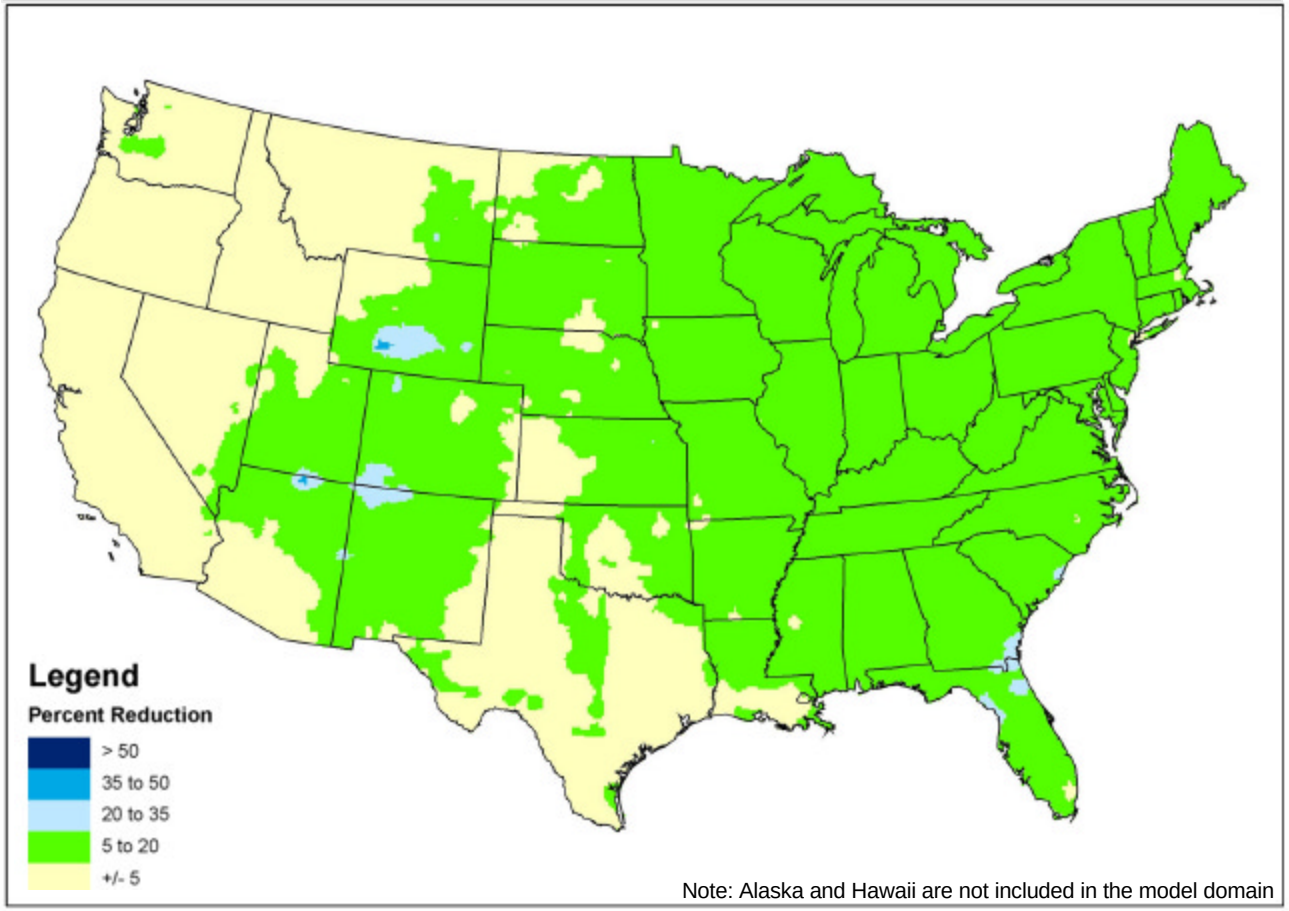
Note: Alaska and Hawaii are not included in the model domain

- The projected large reductions in nitrogen deposition on the West coast are due to existing programs not yet fully implemented, such as the Tier II and Diesel Rules.
- In the West, Clear Skies would prevent further deterioration of air quality, including visibility.
  - Clear Skies would allow growth to occur in the West without increasing NOx emissions.

Note: The increases in nitrogen deposition in Louisiana and Washington state occur under both the Base Case and Clear Skies and are the result of increases in emissions from manufacturing and refining sources.

Clear Skies Nitrogen Deposition Improvements in 2020

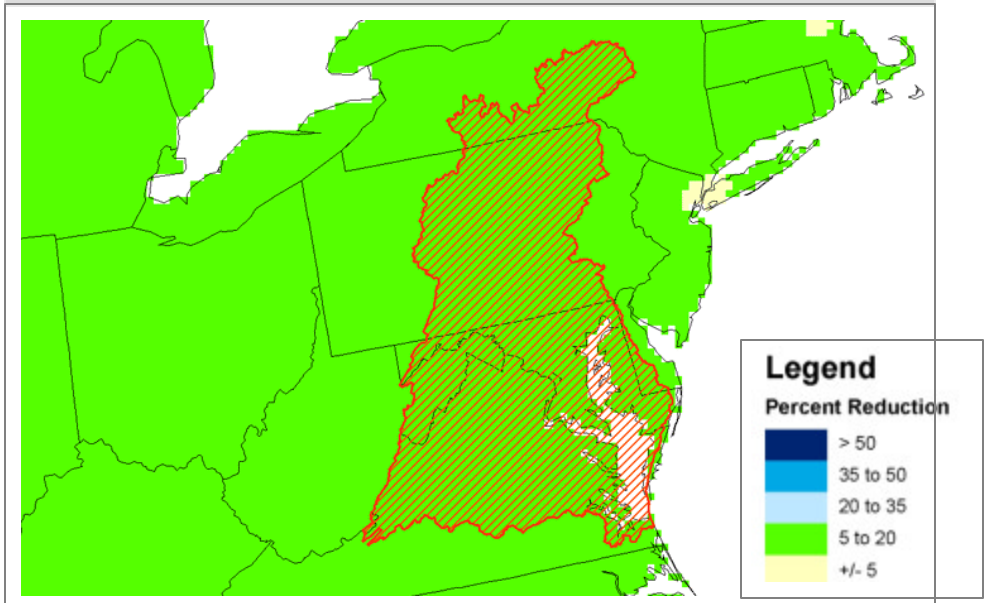
Projected Changes in Nitrogen Deposition with Clear Skies Compared to the Base Case in 2020



- Clear Skies would achieve significant additional reductions of nitrogen deposition of up to 20% beyond what is expected under the Base Case across much of the country, including the East and large portions of the Midwest and West.
- Some areas would experience reductions of up to 35% beyond Base Case levels, including areas in the interior mountain west and nitrogen-sensitive estuarine areas in coastal Georgia.

Clear Skies Reduces Nitrogen Loads to the Chesapeake Bay and Other Estuaries

Projected Change in Nitrogen Deposition with Clear Skies Compared to the Base Case in 2020



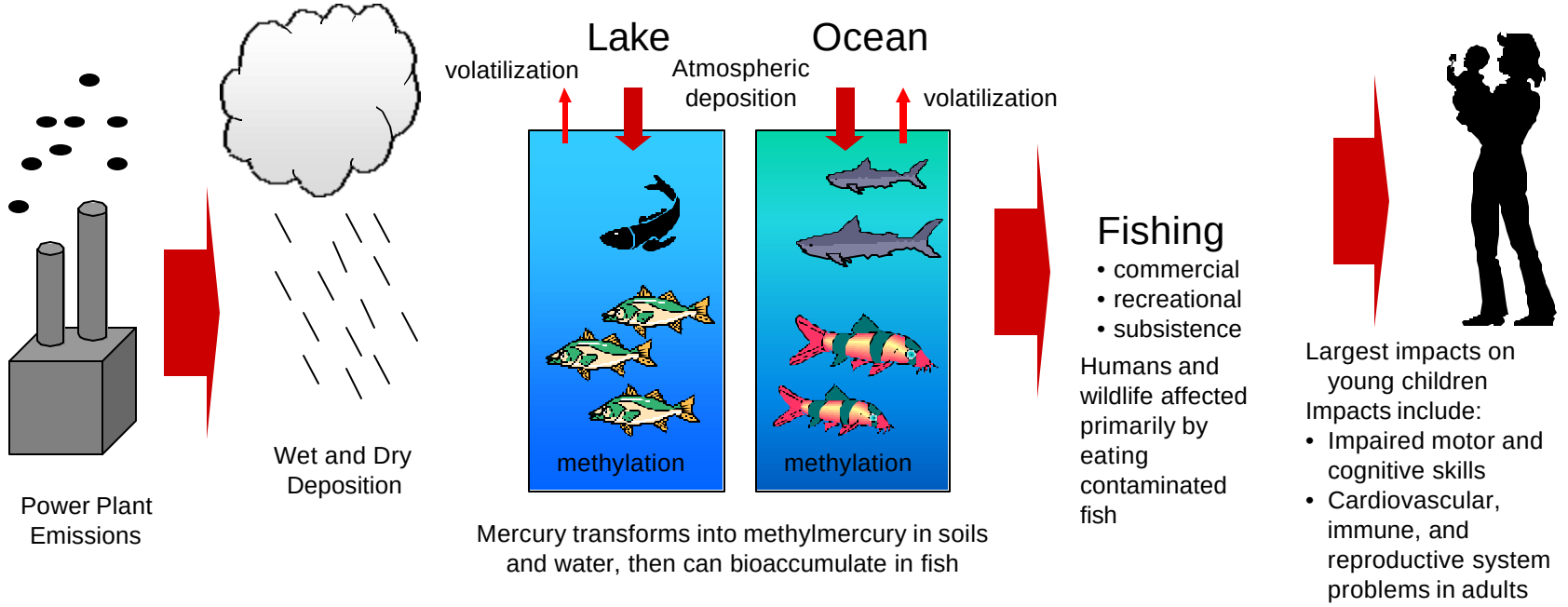
- Under the Clear Skies Act, in 2020, oxidized nitrogen deposition to the Chesapeake Bay watershed would be reduced by up to 20% beyond what is expected under the Base Case.
- Clear Skies is also expected to reduce nitrogen loads to other nitrogen-sensitive estuaries along the East and Gulf coasts by reducing NOx emissions in their airsheds.

NOx Airsheds for Some East and Gulf Coast Estuaries

- These reductions from Clear Skies will help states and estuary management programs meet their nitrogen reduction goals.
  - For example, Chesapeake Bay States, including NY, VA, MD, PA, DE, WV and DC, recently agreed to incorporate the nitrogen reductions that would result from Clear Skies legislation as part of their overall plan to reduce nutrient loadings to the Bay.

Note: An "airshed" depicts a modeled approximation of a large proportion of sources contributing to air quality in a particular receptor region.

Mercury Emissions from Power Plants Contaminate Fish



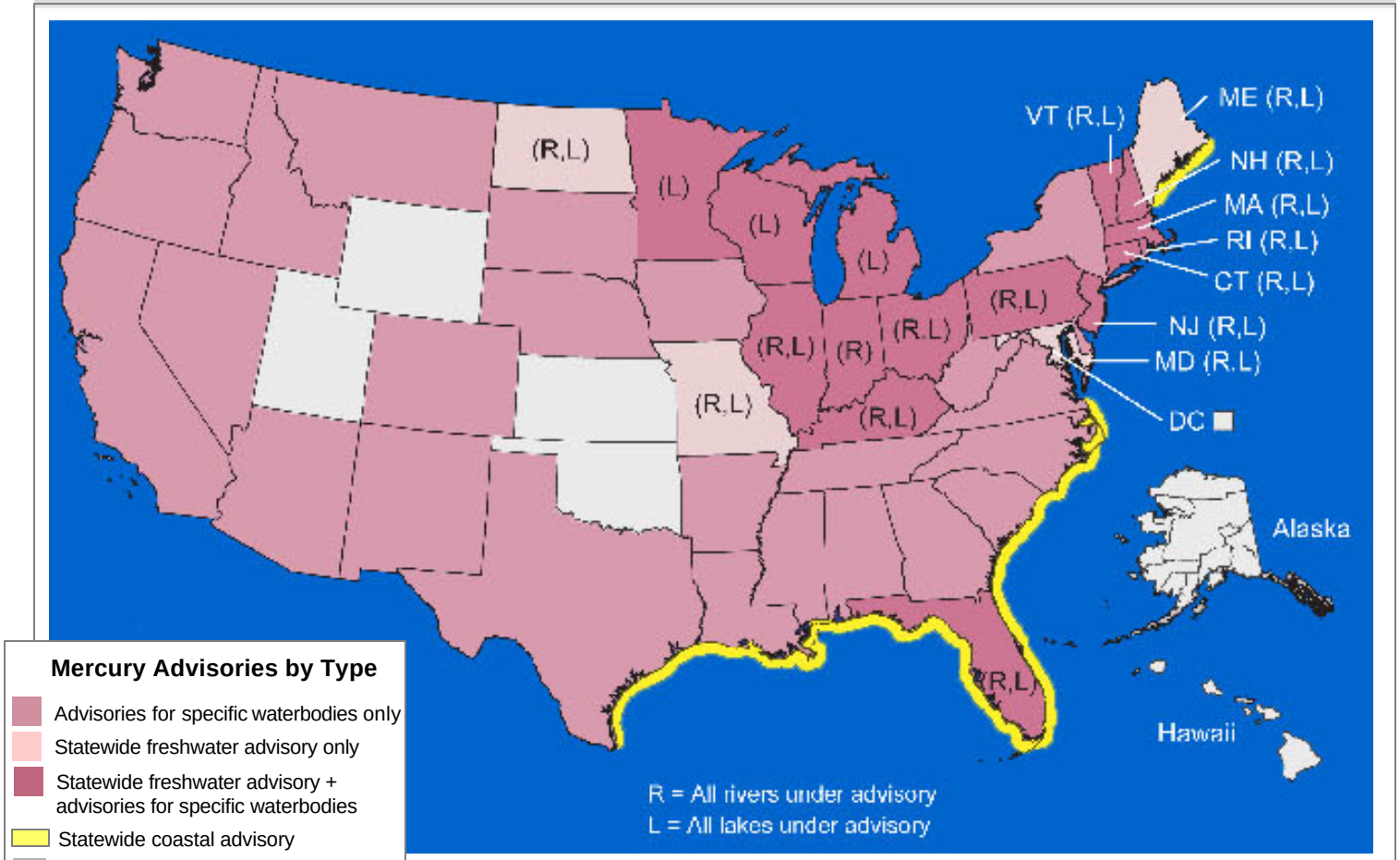
Emissions Reductions → **Reduce Atmospheric Transport and Deposition** → **Reduce Ecosystem Transport and Methylation** → **Reduce Human and Wildlife Exposure** → **Reduce Health Impacts**

- By 2020, Clear Skies implementation would more than double the use of scrubber technology, meaning that approximately 70% of coal generation capacity under Clear Skies would use technology that efficiently reduces the ionic form of mercury from total mercury emissions.
- As a result of Clear Skies, ionic mercury emissions are projected to be 62% lower than emissions levels under the Base Case.
- Ionic mercury emissions are responsible for the majority of short-range transport and deposition, the local impacts of mercury emissions.
- 60% of deposition in the U.S. comes from current U.S. anthropogenic sources (primarily coal-combustion sources).
- Mercury deposition is a significant source of mercury to many waterbodies. For example, mercury deposited from the atmosphere accounts for more than 50% of the mercury input to the Chesapeake Bay and to Lake Michigan.
- Most people are exposed to mercury through eating contaminated fish. Developing fetuses are most at risk for neurological harm due to mercury.

Mercury Contamination in Fish

- Currently 44 states have issue fish consumption advisories for some or all of their waters due to contamination from mercury.*

States with Fish Advisories Due to Mercury



***Note:** For more information about the relationship between fish advisories and human exposure to mercury, see the EPA Report "America's Children and the Environment: Measures of Contaminants, Body Burdens, and Illnesses" available at *http://yosemite.epa.gov/ochp/ochpweb.nsf/content/publications.htm*

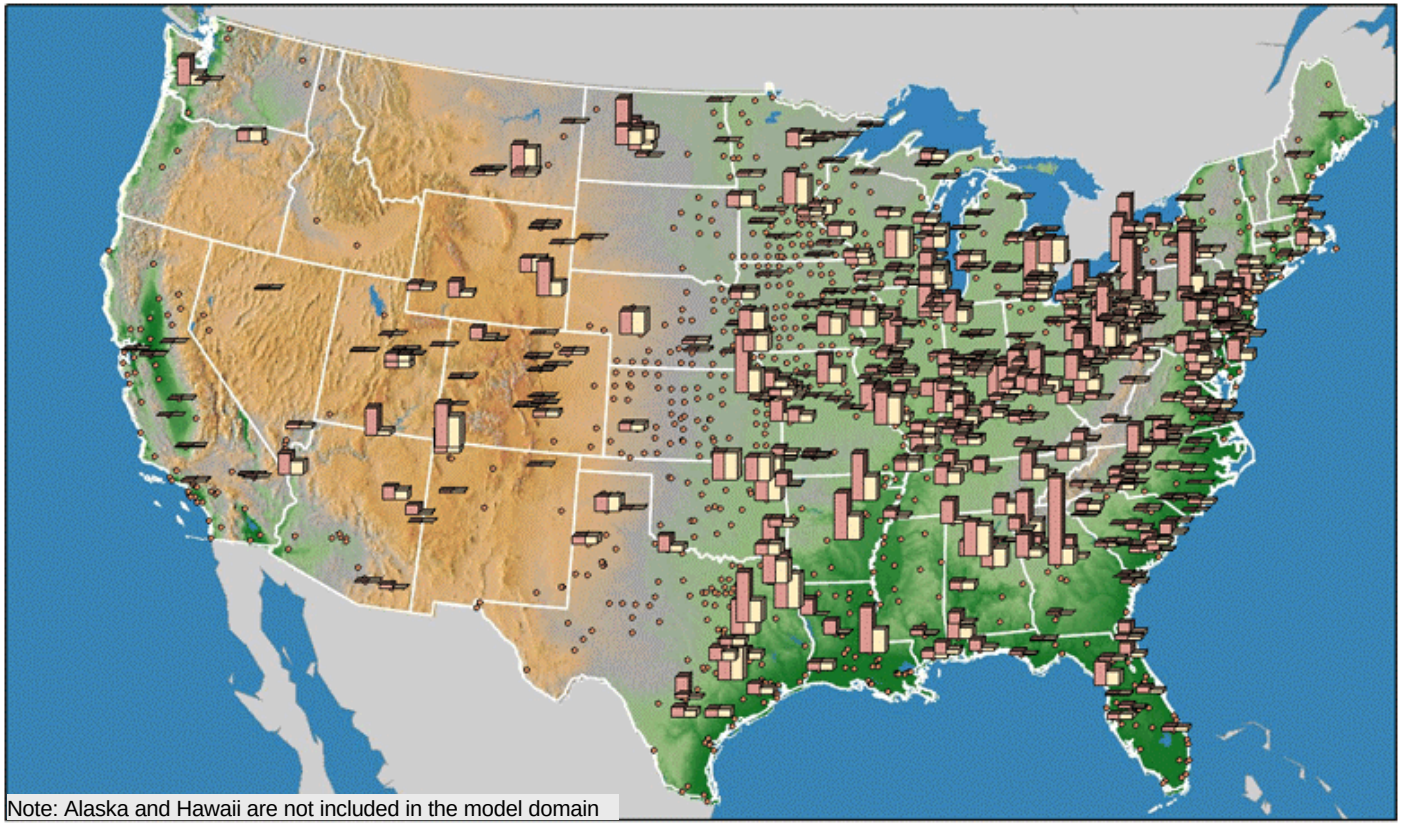
Emerging Data from the METAALICUS Study

- Emerging research indicates that reducing atmospheric deposition from sources that are currently emitting mercury can have a large impact on fish tissue concentrations.
- Researchers have found that isotopically-labeled ("spiked") mercury deposited to the lake surface was found in northern pike--a top predator--within a few months of being deposited.
- Data also indicates that "spiked" mercury deposited to the surface of the lake in the summer of 2001 comprised 30% of the mercury that accumulated in perch fish tissue the following summer.
- Although still preliminary, based on this information it is reasonable to assume that reductions in mercury deposition can reduce mercury concentrations in fish within a few months to a few years.

METAALICUS

- METAALICUS is a large research effort involving over 30 principle investigators on a lake in the Experimental Lakes Area of western Ontario and funded by a wide variety of government, academic, and research organizations, including the USEPA and EPRI.
- The researchers added 3 separate stable isotopes of mercury to the uplands, wetland, and lake areas in the summers of 2001, 2002, and 2003.
- The researchers are measuring mercury concentrations in plants, animals, soils, and sediments throughout the lake and its watershed to understand how mercury moves through a watershed.
- Researchers have begun analyzing the data from the first two field seasons and will be submitting manuscripts for publication over the next few months.

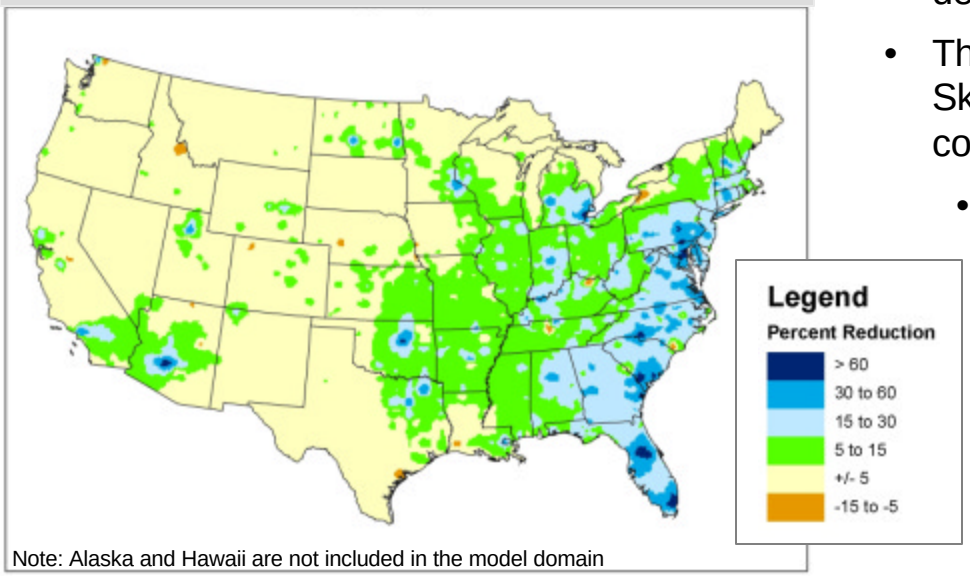
Clear Skies Is Expected to Reduce Mercury Emissions Throughout the U.S.



Projected Mercury Emissions from Coal-Fired Power Plants with Clear Skies and the Base Case in 2020

Mercury Deposition Improvements in 2020

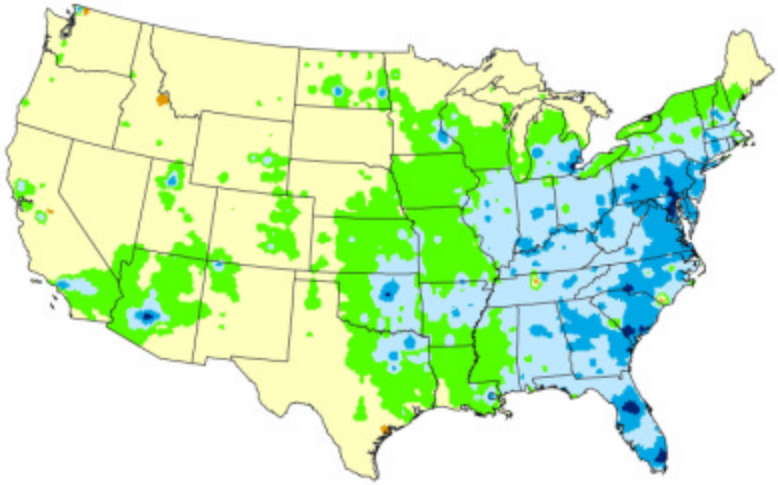
Projected Changes in Mercury Deposition with the Base Case in 2020 Compared to 2001



Note: Alaska and Hawaii are not included in the model domain

- The top map demonstrates the effects of existing programs (Base Case) in comparison to current deposition levels.
- The bottom map demonstrates the effects of Clear Skies in combination with the Base Case in comparison to current deposition levels.
  - Clear Skies would, together with the Base Case, contribute to a 15-60%* reduction in mercury deposition from current levels throughout the East and Midwest.

Projected Changes in Mercury Deposition with Clear Skies and the Base Case in 2020 Compared to 2001



Note: Alaska and Hawaii are not included in the model domain

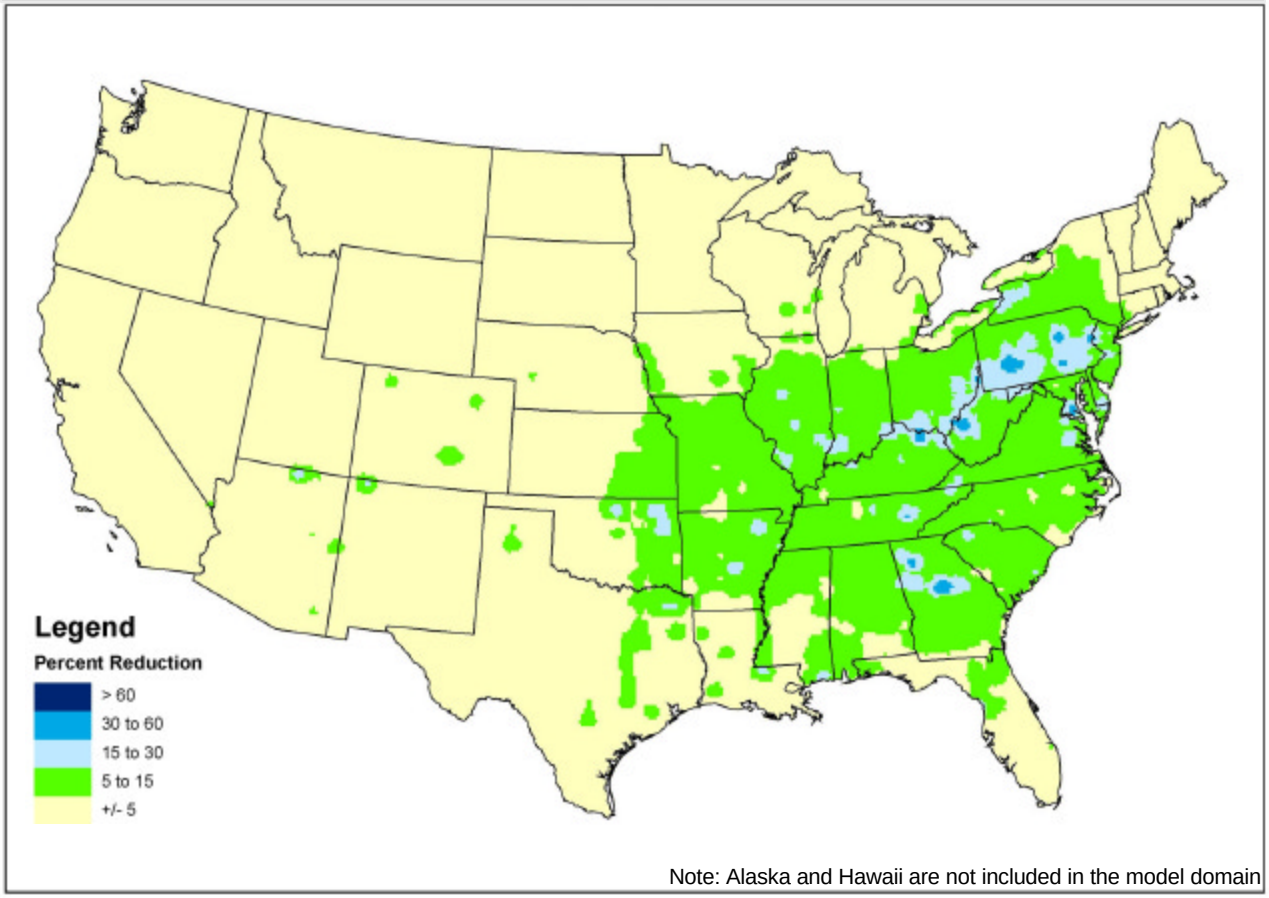
- Deposition reductions are expected to occur in many places where fish advisories are in effect due to elevated levels of mercury.
  - For example, ecosystems in Florida have already been shown to respond quickly to changes in mercury loads.
    - Over half the reductions in fish tissue concentrations took place in the first ten years.

***** These results are based on modeling the Clear Skies mercury cap without triggering the safety valve.

Note: The increases in mercury deposition occur under the Base Case and with Clear Skies and are the result of increases in emissions from sources other than power plants that are not affected by Clear Skies.

Clear Skies Mercury Deposition Improvements in 2020

Projected Changes in Mercury Deposition with Clear Skies Compared to the Base Case in 2020

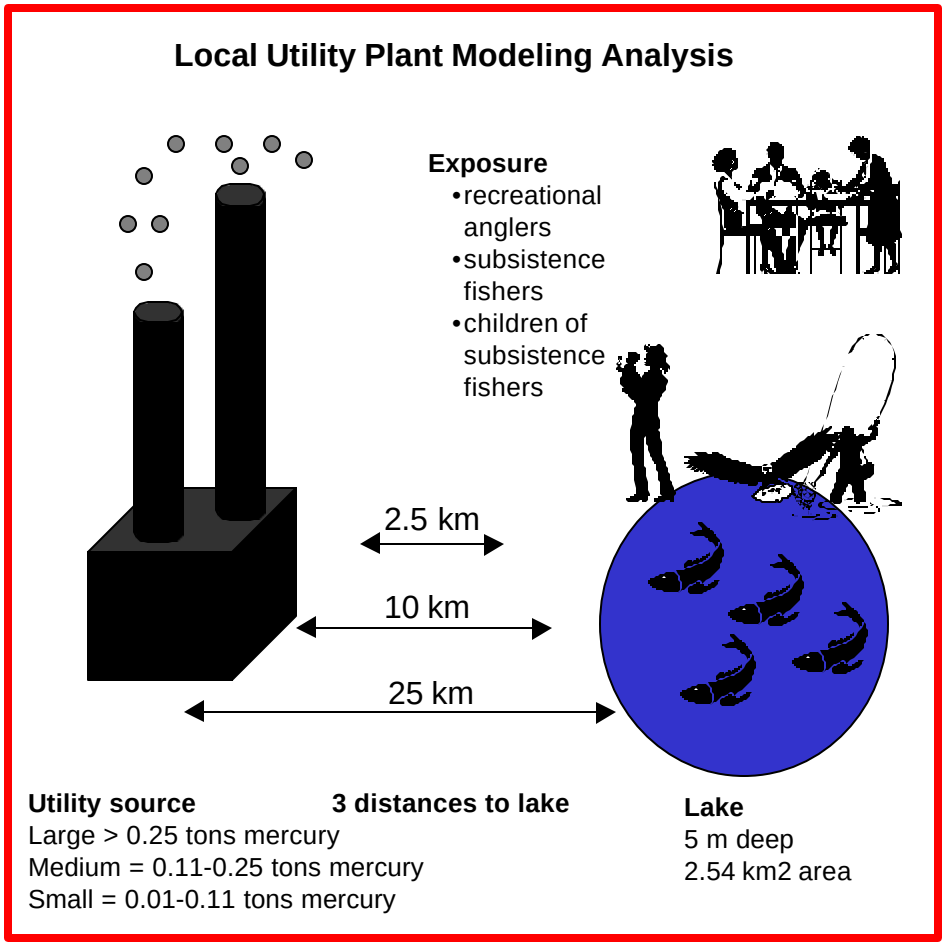


- Considering Clear Skies without the safety valve, Clear Skies could potentially reduce mercury deposition 5-15%* beyond the Base Case across much of the East.
  - In some areas mercury deposition would be reduced up to 60%.

***** These results are based on modeling the Clear Skies mercury cap without triggering the safety valve.

EPA's Assessment of Mercury from Local Power Plants from the 1997 Utility Study Report to Congress

- Almost all sensitive populations in the study (recreational anglers, subsistence fishers, and children of subsistence fishers) eating fish from a lake within 25 km of a coal-fired power plant are exposed to mercury above the level of the reference dose (RfD).
    - In some cases the exposure is 10 times the RfD.
- Large coal-fired utilities (emitting > 0.25 tons of mercury) within 10 km are the dominant source of mercury to fish in these waters.
- Medium coal-fired utilities (emitting 0.11-0.25 tons of mercury) within 2.5 km are the dominant source of mercury to fish in these waters.

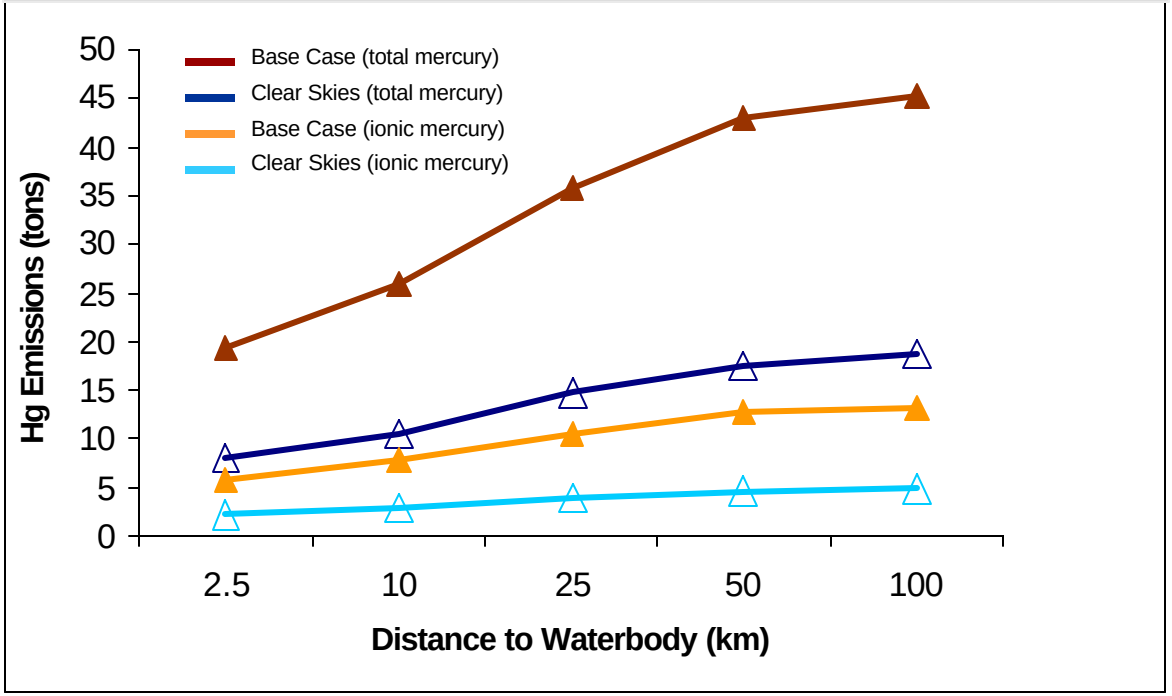


Local Hg Risk assessment requires air quality/deposition model, Hg cycling model for lake/fish/other biota, population exposure model or assumptions

Case Study: Mercury Emissions from Sources Near Waterbodies*

- 3 large sources (emitting greater then 0.25 tons of mercury) in the U.S. are located within 10 km of a body of water.
- 17 large and medium sources (emitting greater then 0.11 tons of mercury) are located within 2.5 km of a waterbody.
- Ionic mercury emissions from all power plants within 10 km of a waterbody are expected to decrease 63% from the Base Case under Clear Skies in 2020.
- Ionic mercury emissions from all power plants within 2.5 km of a waterbody are also expected to decrease 62%.

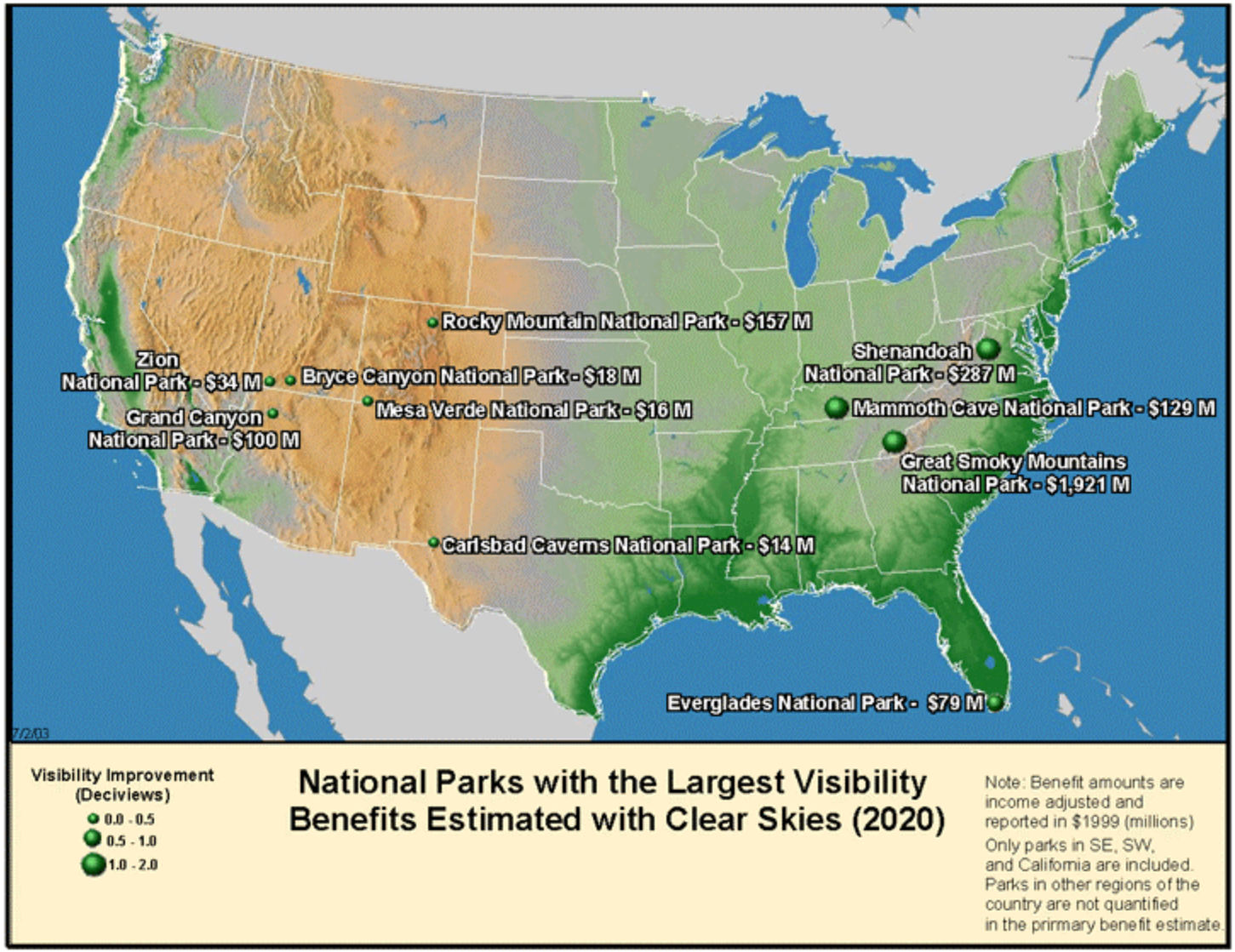
Projected Mercury Emissions Near Waterbodies with Clear Skies and the Base Case in 2020



***** These results are based on modeling the Clear Skies mercury cap without triggering the safety valve.


Case Study
Clear Skies
and
National Parks

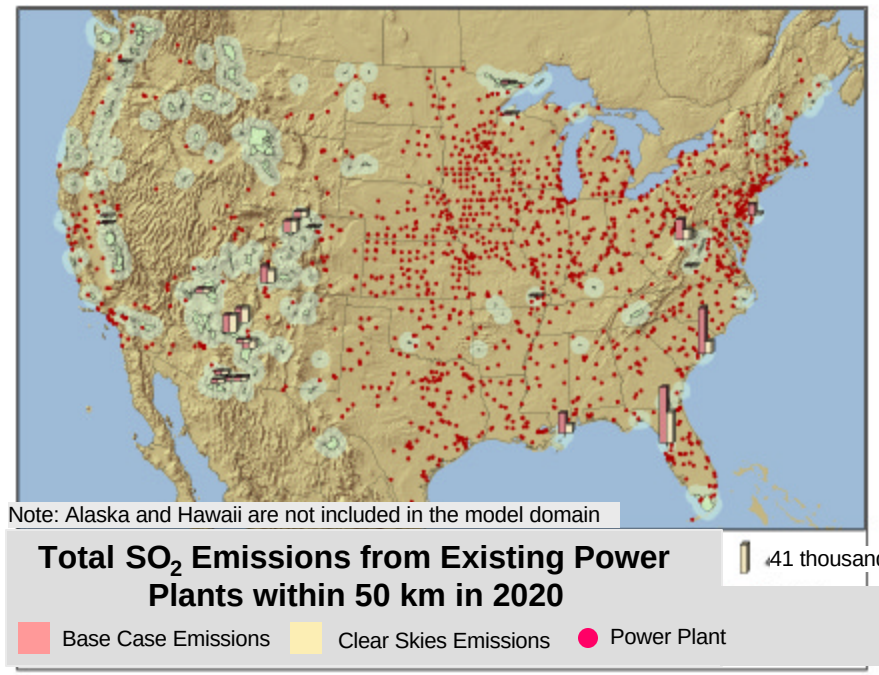
Visibility Benefits in National Parks

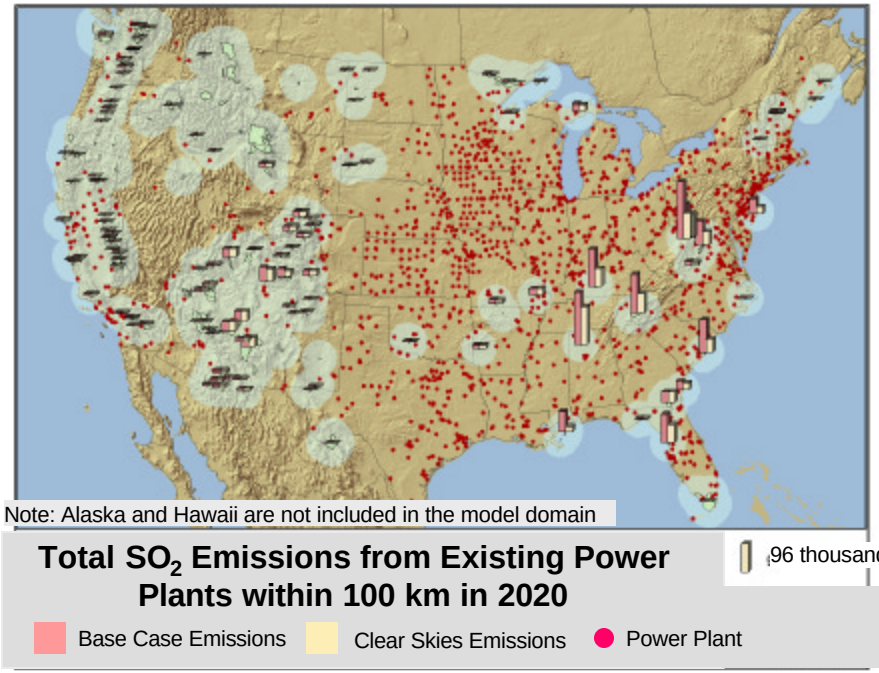


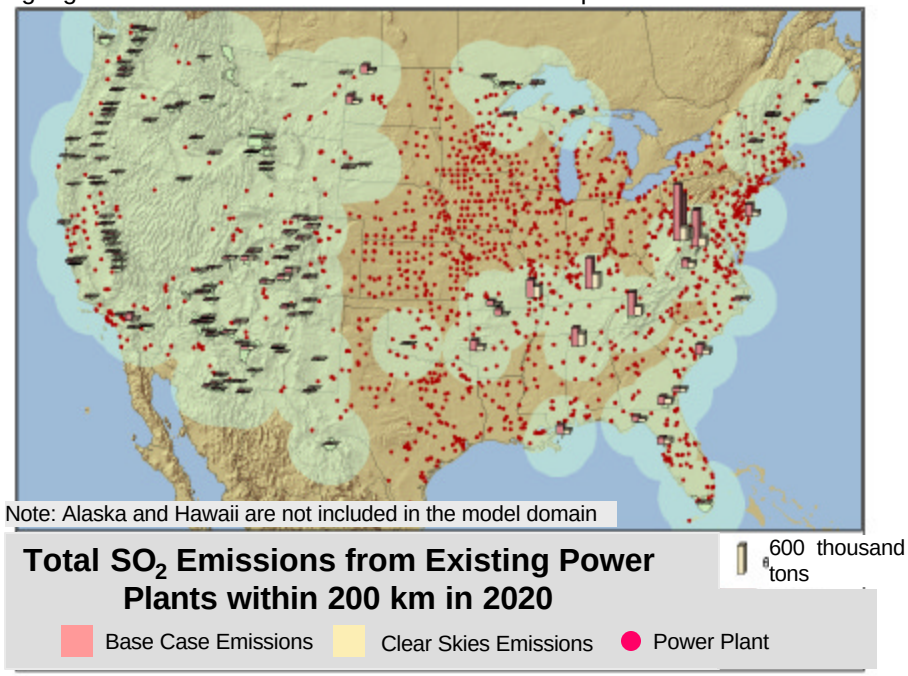
SO_2 Emissions from Existing Sources near Class I Areas

- SO_2 emissions from existing power plants are expected to be significantly lower in the areas surrounding Class I areas under Clear Skies

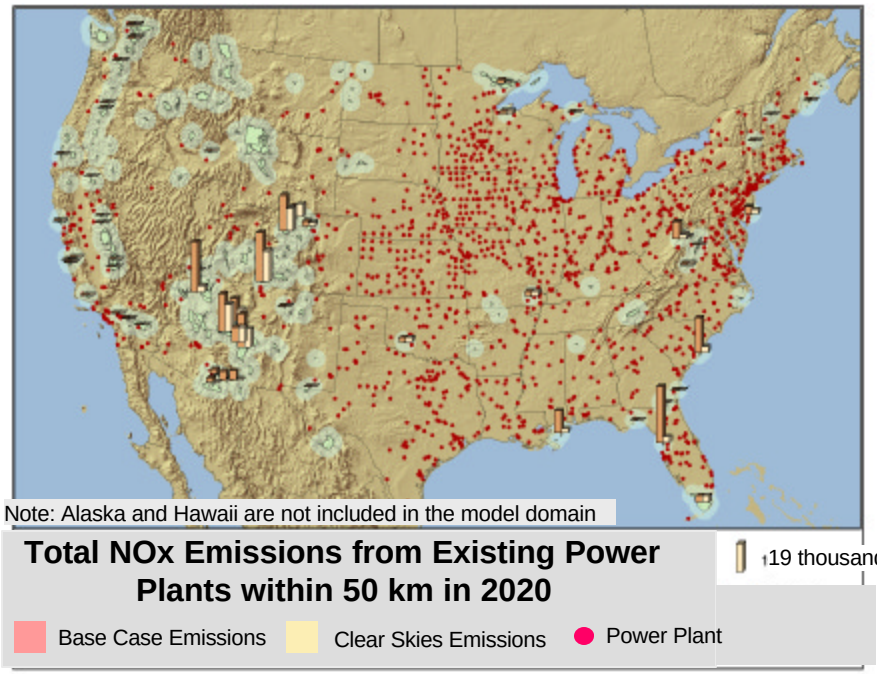
Notes: Bars represent sum of emissions from sources within each highlighted area. Scales are different for each map.





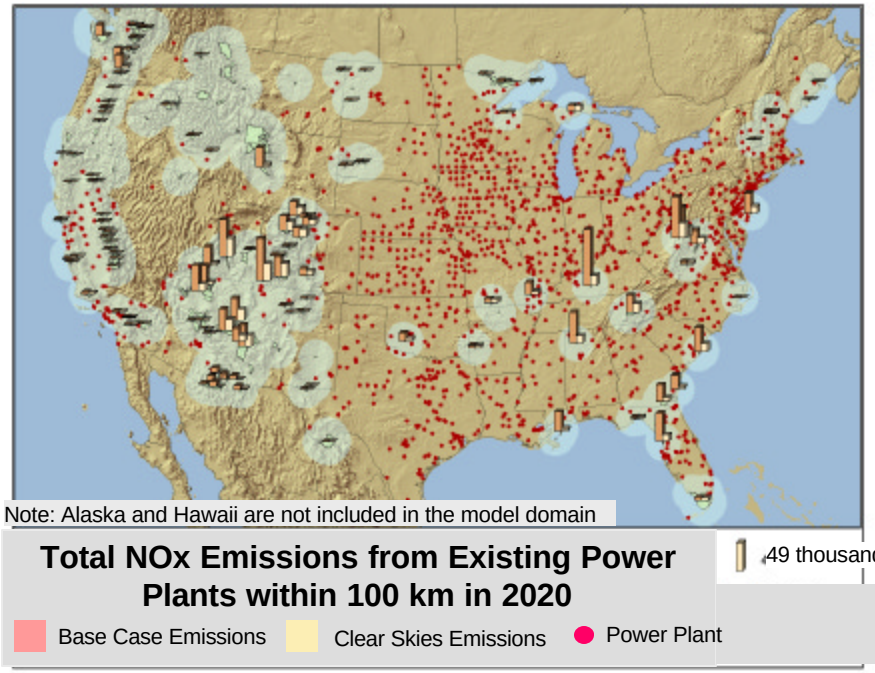


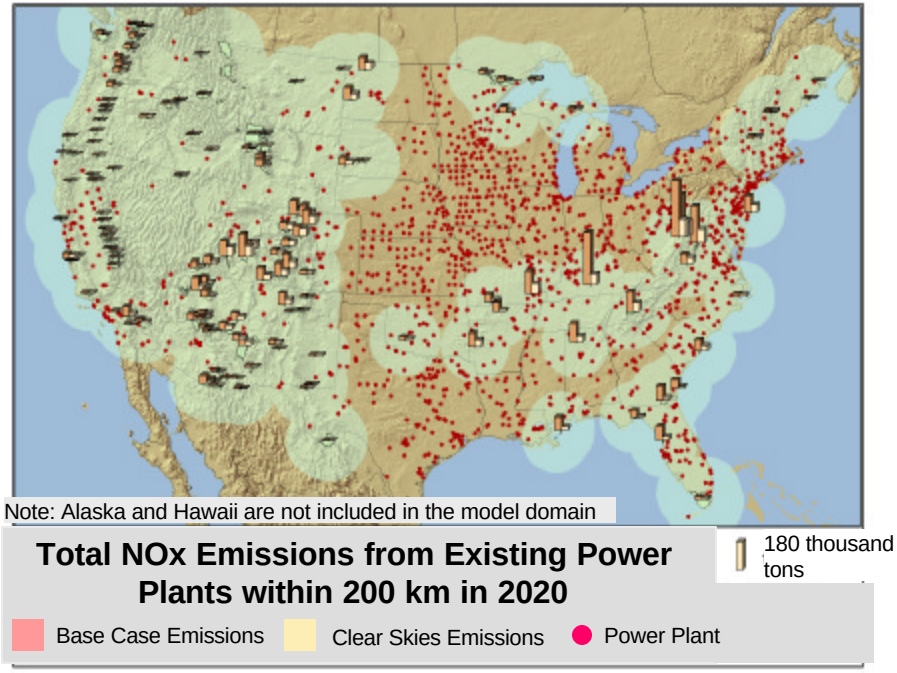
NOx Emissions from Existing Sources near Class I Areas



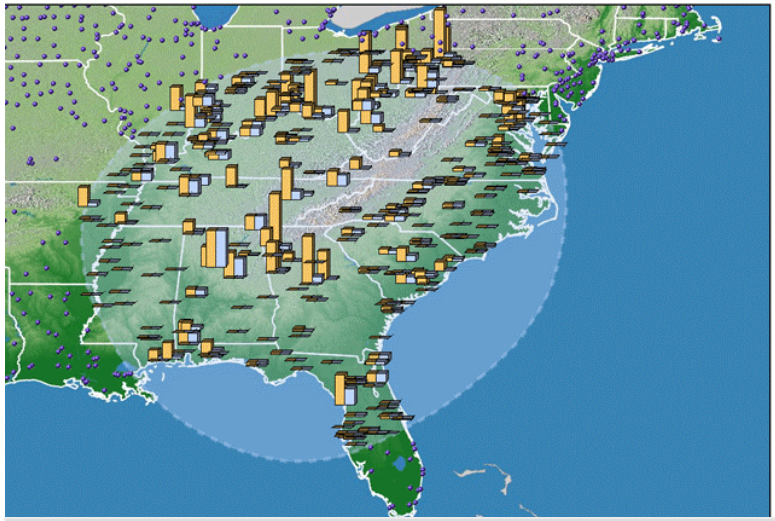
- NOx emissions from existing power plants are expected to be significantly lower in the areas surrounding Class I areas under Clear Skies.

Notes: Bars represent sum of emissions from sources within each highlighted area. Scales are different for each map.





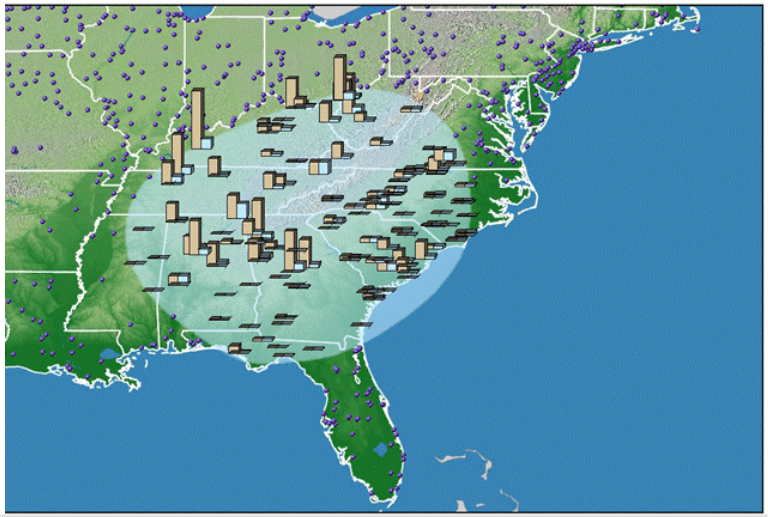
Airsheds for the Southern Blue Ridge Mountains



Projected SO_2 Emissions from Existing Power Generation Sources in the Southern Blue Ridge Airshed in 2020

Base Case | Clear Skies | sulfur airshed

Scale: 75,000 tons | other fossil fuel power plants



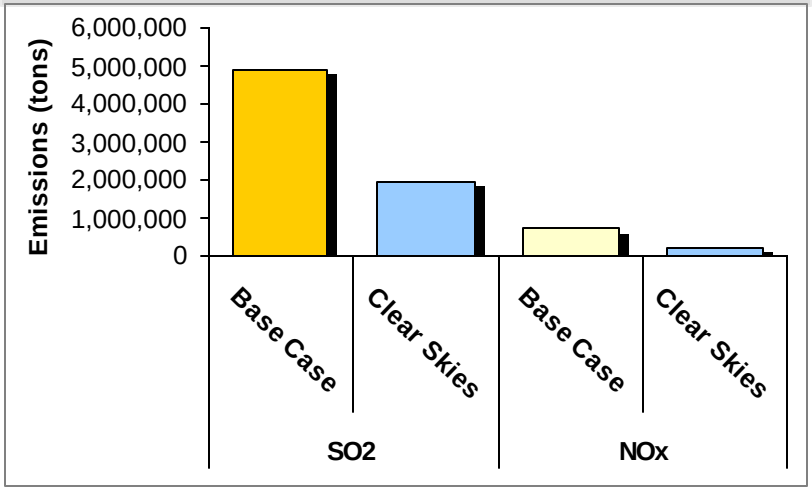
Projected NOx Emissions from Existing Power Generation Sources in the Southern Blue Ridge Airshed in 2020

Base Case | Clear Skies | nitrogen airshed

Scale: 22,000 tons | other fossil fuel power plants

- This page shows regional airshed maps that were developed for the Southern Blue Ridge Mountains (which includes Great Smoky Mountain National Park).
- Multiple emission sources in numerous states contribute to air quality degradation and acid deposition in the Southern Blue Ridge region.
- In 2020, emissions from power plants in the Southern Blue Ridge region are projected to be substantially lower with Clear Skies than under the Base Case:
  - SO_2 emissions are projected to decrease 61%;
  - NOx emissions are projected to decrease 68%.

SO_2 and NOx Emissions in the Airsheds (2020)



Note: An "airshed" depicts a modeled approximation of a large proportion of sources contributing to air quality in a particular receptor region.

Notes on the Health and Visibility Benefits of Clear Skies

[1] The ozone benefits were calculated for the eastern U.S. and portions of the West where significant ozone changes are expected; therefore the total national benefits from reductions in ozone may be slightly higher than what is reflected here.

[2] The two sets of estimates reflect alternative assumptions and analytical approaches regarding quantifying and evaluating the effects of airborne particles on public health. All estimates assume that particles are causally associated with health effects, and that all components have the same toxicity. Linear concentration-response relationships between PM and all health effects are assumed, indicating that reductions in PM have the same impact on health outcomes regardless of the absolute level of PM in a given location. The base estimate relies on estimates of the potential cumulative effect of long-term exposure to particles, while the alternative estimate presumes that PM effects are limited to those that accumulate over much shorter time periods. All such estimates are subject to a number of assumptions and uncertainties. (It is of note that, based on recent findings from the Health Effects Institute, the magnitude of mortality from short-term exposure (alternative estimates) and hospital/ER admissions estimates (both estimates) may be overstated.) The alternatives also use different approaches to value health effects damages. The key assumptions, uncertainties, and valuation methodologies underlying the approaches used to produce these results are detailed in the proposed Non-road Diesel Regulatory Impact Assessment (*http://www.epa.gov/nonroad/*) and will soon be available on the Clear Skies website in Technical Addendum: Methodologies for Benefit Analysis of the Clear Skies Act, 2003.

[3]Visibility improves as the concentration of airborne fine particles declines. Based upon emissions reductions under Clear Skies, this analysis calculated changes in air quality and in visibility, measured in terms of deciviews. (A deciview is a standard measure of visibility change; a one or two deciview change translates to a noticeable change in visibility for most individuals.) Consistent with previous approaches, the valuation of visibility improvements is limited to a subset of National Parks and Wilderness Areas and does not include residential areas. Because of this limitation, visibility benefits of the Clear Skies Act are expected to be greater than this primary estimate.