Section B:

Human Health and Environmental Benefits

Overview of the Assessment

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

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
- Acid Deposition (sulfur and nitrogen deposition)
- Freshwater Acidification
- Mercury Emissions
- Mercury Deposition

The assessment 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 $PM_{2.5}$ and ozone are estimated to be $96 billion annually (1999$), including:

- $93 billion in annual human health benefits. This would include the value of avoiding:
  - 11,900 premature deaths;
  - 7,400 new cases of chronic bronchitis;
  - 11,900 total hospitalizations and emergency room visits for cardiovascular and respiratory symptoms;
    - 2,900 fewer emergency room visits for asthma attacks.
  - 15 million days with respiratory-related symptoms, including work loss days, restricted activity days, and asthma attacks;
    - 370,000 days with asthma attacks;
- An alternative estimate projects over 7,000 premature deaths prevented and $11 billion in health benefits annually by 2020.
- $3 billion in annual visibility benefits from improving visibility at select National Parks and Wilderness Areas. Note that visibility benefits would likely increase if emissions reductions under the WRAP were included in this analysis.
- There are additional health and environmental benefits, such as reduced human exposure to mercury and fewer acidified lakes, that cannot currently be quantified or monetized but nevertheless are expected to be significant.

By 2020, based on initial modeling, Clear Skies is expected to:

- bring 54 additional counties, home to approximately 21 million people, into attainment with the new fine particle standard as compared to existing programs (Base Case). The remaining counties are expected to move closer to attainment.
- bring 8 additional counties, home to 4 million people, into attainment with the new ozone standard as compared to existing programs. The remaining counties are expected to move closer to attainment.

Summary of Results *cont'd*

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 more than 20%;
- Improve visibility in a large portion of the East and Midwest by 2-3 deciviews from current levels; in areas of the southern Appalachian Mountains (e.g. Great Smoky Mountain National Park) visibility would improve more than 3 deciviews;*
- 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) over much of the sensitive eastern U.S., including coastal areas, by up to 60%; and
- Virtually eliminate chronic acidity -- the most serious form of acidification -- in Northeastern lakes (including those in Adirondack Park) and prevent further deterioration of acidic Southeastern streams.

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

- Reduce fine particle concentrations in the East and Midwest by 10-20%;
- Improve visibility in the East and Midwest by 1-2 deciviews;
- Reduce sulfur deposition to sensitive ecosystems in the East by more than 30%; and
- Reduce nitrogen deposition across the East by 15-30%.

Note: 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 or two deciview change translates to a noticeable change in visibility for most individuals.

Air Quality Modeling: Base Case and Clear Skies

What is included in the air quality modeling Base Case?

The air quality Base Case includes all finalized EPA 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
- the NOx SIP Call
- the Tier 2 rule for new cars and light trucks
- the Heavy Duty Diesel truck rules for 2004 and 2007 covering new vehicles
- additional state regulatory requirements in finalized form by 2000

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

The air quality Base Case does not include:

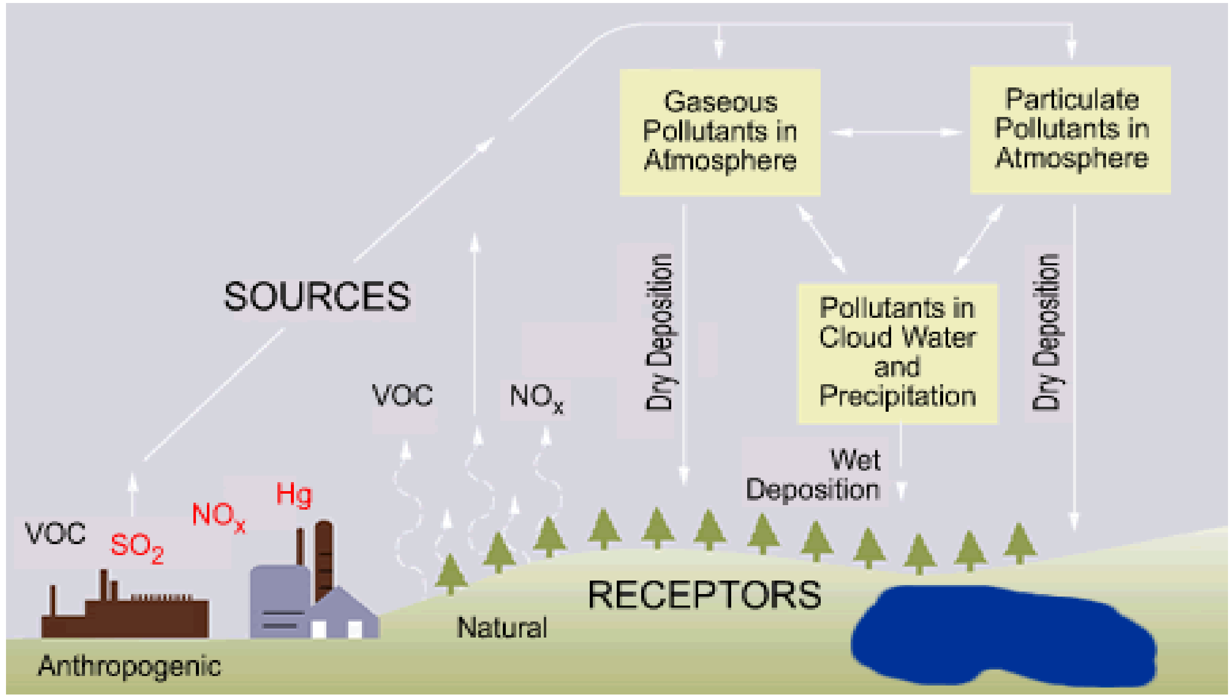
- Proposed or planned major regulations that the EPA will pursue in addition to the Clear Skies Act to lower emissions across the country. (e.g. EPA plans to propose substantial controls on non-road diesel sources).
- Voluntary emissions reduction programs, such as the diesel retrofit program, and pending federal enforcement actions that are not predictable.
- Additions to State Implementation Plans to ensure compliance with the NAAQS or some *very* recent/pending state laws, such as the one in North Carolina, that address air pollution.

What is included in the Clear Skies air quality Case?

The Clear Skies Case includes all projected Base Case emissions minus the reductions in SO_2,NOx, and mercury that would be achieved by the Clear Skies Act.

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

- When emitted into the atmosphere, sulfur dioxide, nitrogen oxides, and mercury undergo chemical reactions to form compounds that 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 by means of rain, sleet, snow, and fog.
- 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.

Overview of the Health and Environmental Effects of SO_2, NOx, and Mercury

Effects of Nitrogen Oxides (NOx)

- Contributes to premature death and serious respiratory illness (e.g., asthma, chronic bronchitis) due to fine particles and ozone.
- 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).
- Contributes to “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 illness (e.g., asthma, chronic bronchitis) 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.

How Do Fine Particles ($PM_{2.5}$) Affect 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 microns (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;
  - Increased work loss days, school absences, and emergency room visits; and
  - Changes to lung structure and natural defense mechanisms.

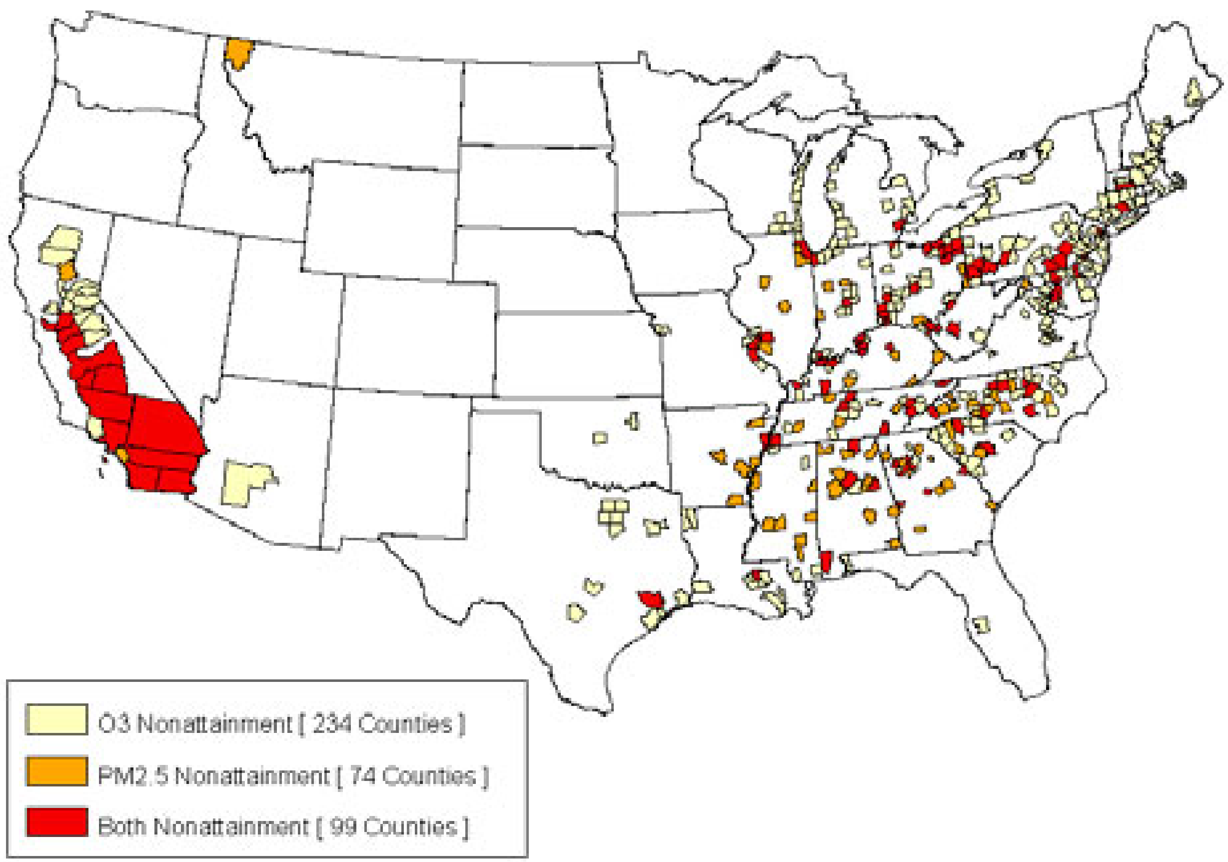
How Does Ozone (Smog) Affect Human Health and Vegetation?

- 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.

Attainment with $PM_{2.5}$ and 8-hour Ozone Standards (Current Data*)

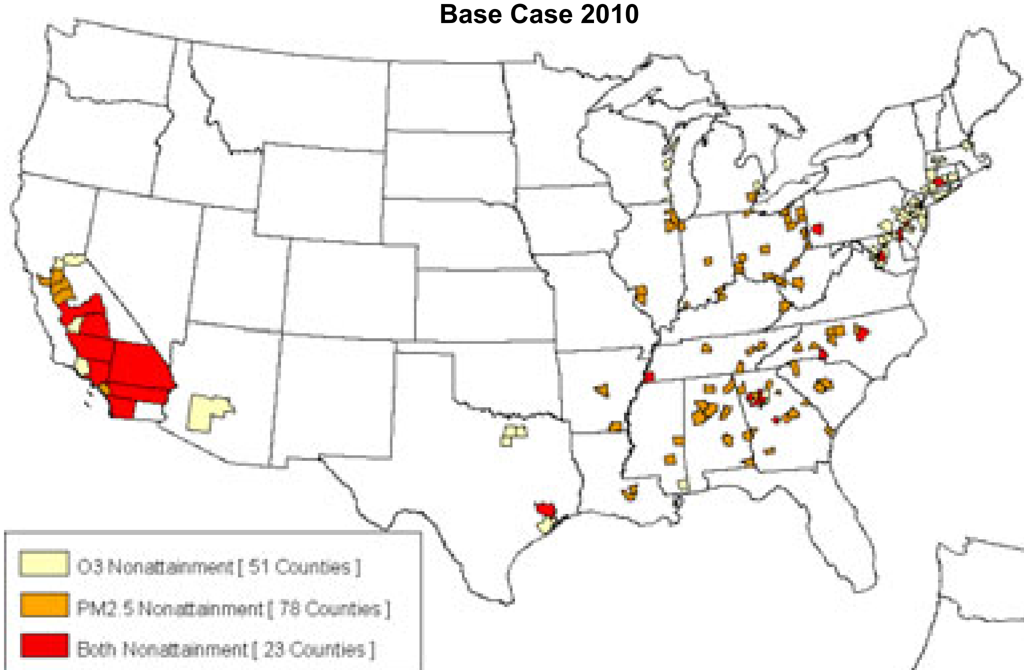
- Based on available 1999-2000 $PM_{2.5}$ data, 157 counties in the East and 173 counties nationwide are likely to exceed the fine particle standard (projected concentrations greater than 15 μ/m^3, which is the annual fine particle standard).
  - Currently 82 million people nationwide, including 59 million in the East, live in counties that would not meet the standard.
- There are currently 333 counties (306 counties in the east) estimated to exceed the 8-hour ozone standard.
  - Currently 120 million people live in counties with projected ozone concentrations greater than 85 ppb (the 8-hour ozone standard).



Note: To permit comparisons among various analyses, the air quality data were the most complete and recently available as of mid-2001 (1997-1999 ozone monitoring data and 1999-2000 $PM_{2.5}$ data). More complete and recent air quality data for ozone and fine particles (1999-2001 data) is now available. This updated data indicate differences in the likely attainment status of some counties compared to what is shown here. Future analyses of Clear Skies will incorporate the most recent data available.

Projected Attainment with $PM_{2.5}$ and 8-hour Ozone Standards under Clear Skies (2010)

Base Case 2010

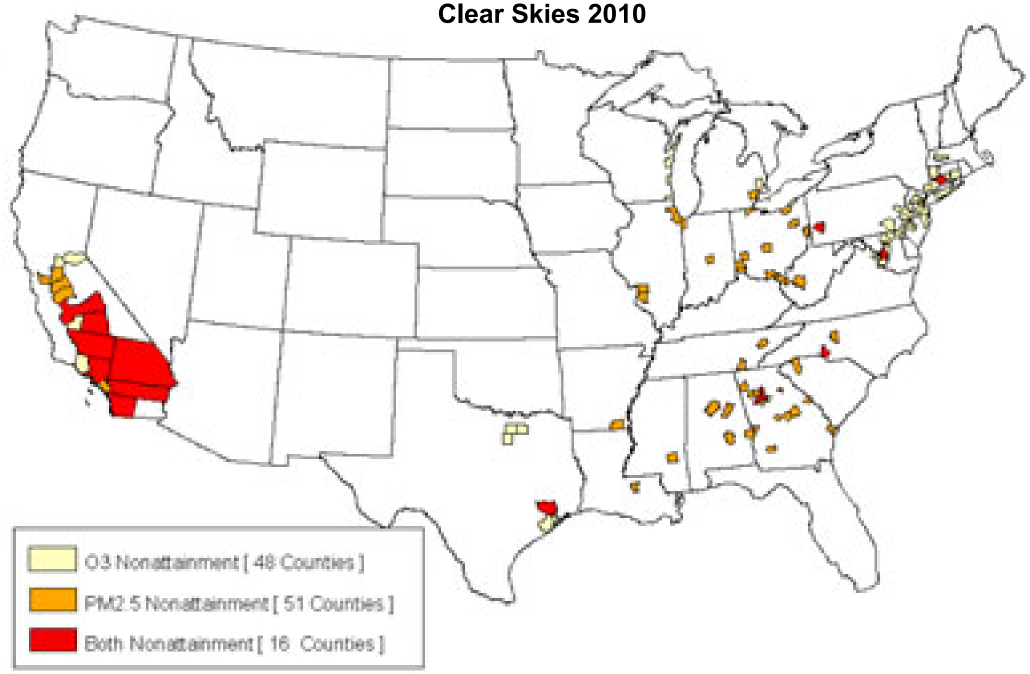


The Clear Skies Act would result in a substantial number of counties meeting the $PM_{2.5}$ and 8-hour ozone standards sooner than they would under the existing Clean Air Act.

$PM_{2.5}$ attainment status in 2010:

- Based on initial modeling, the Clear Skies Act would bring 34 additional counties (home to approximately 10 million people) into attainment with the fine particle standard (as compared to the Base Case).

Clear Skies 2010



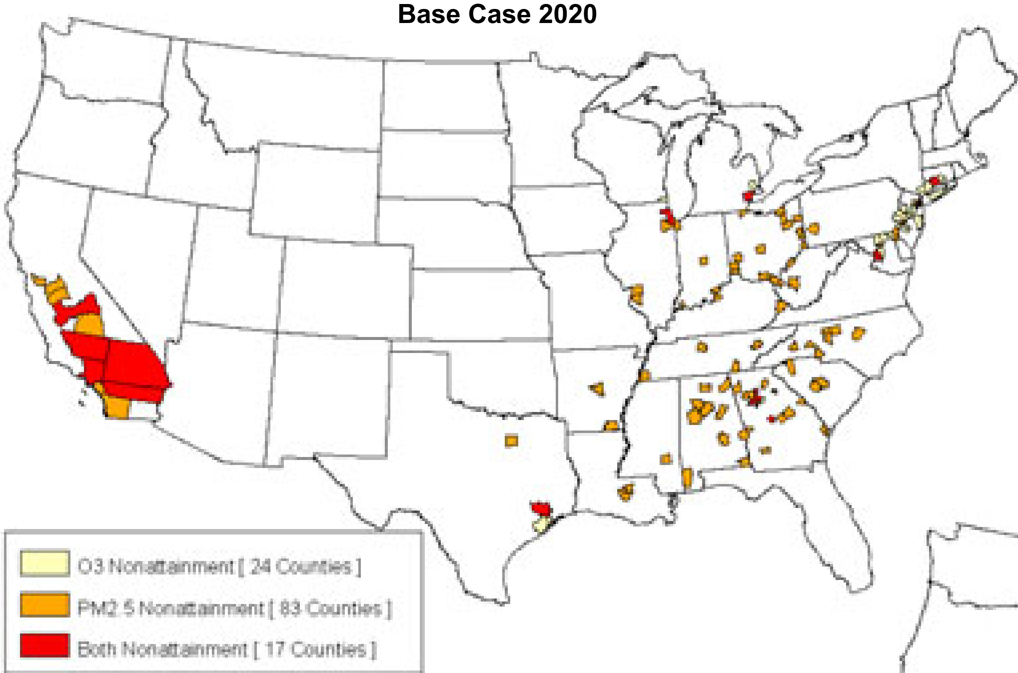
Ozone attainment status in 2010:

- Based on initial modeling, the Clear Skies Act would bring 10 additional counties (home to over 7 million people) into attainment with the 8-hour ozone standard in 2010 (as compared to the Base Case).

Note: This analysis shows the counties that would come into attainment due to Clear Skies alone in 2010. Additional federal and state programs are designed to bring all counties into attainment by 2017 at the latest.

Projected Attainment with $PM_{2.5}$ and 8-hour Ozone Standards under Clear Skies (2020)

Base Case 2020



$PM_{2.5}$ attainment status in 2020:

- Based on initial modeling, the Clear Skies Act would bring 54 additional counties (home to approximately 21 million people) into attainment with the fine particle standard (as compared to the Base Case).

Ozone attainment status in 2020:

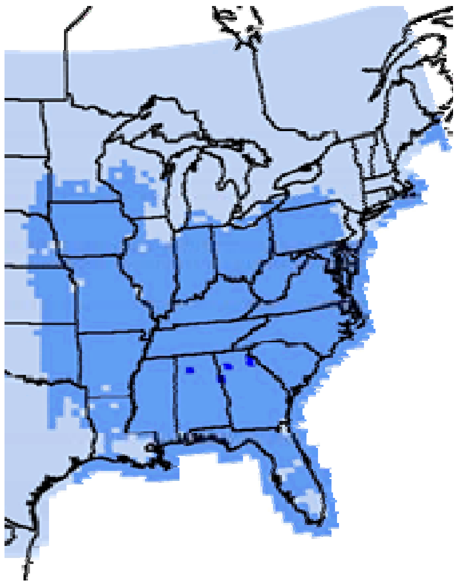
- Based on initial modeling, the Clear Skies Act would bring 8 additional counties (home to over 4 million people) into attainment with the 8-hour ozone standard (as compared to the Base Case).

Note: This analysis shows the counties that would come into attainment due to Clear Skies alone in 2020. Additional federal and state programs are designed to bring all counties into attainment by 2017 at the latest.

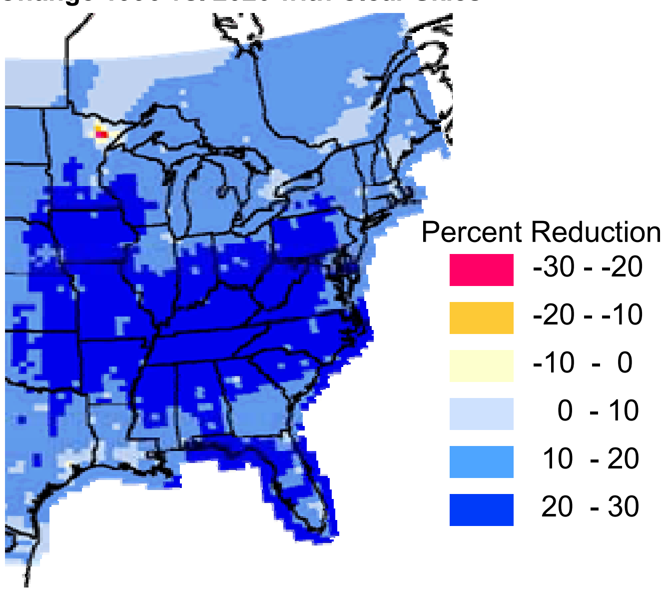
Clear Skies 2020

Fine Particle Concentrations (2020)

Percent Change Base Case vs. Clear Skies in 2020



Percent Change 1996 vs. 2020 with Clear Skies



- SO_2 and NOx emissions produce a substantial fraction of fine particle concentrations, particularly in the East.
- The top map shows that Clear Skies would reduce fine particle concentrations in the East and Midwest 10-20% beyond what is expected under the Base Case.
- The bottom map demonstrates that fine particle concentrations in a large portion of the East and Midwest would improve more than 20% from current levels under Clear Skies and existing programs.

Notes: Title IV reduced over 3 million tons of SO_2 between 1990 and 1996 that are not captured by the improvements shown on the map because the base year for the analysis was 1996.

Emissions from certain sources, such as mining and metals processing, are expected to increase in the future. These sources, which are not affected by Title IV or Clear Skies, contribute to increases in fine particle concentrations in certain areas (e.g. Northern Minnesota).

The western U.S. is not shown in these maps because the SO_2 emissions reductions expected from the WRAP have not yet been included in the air quality modeling analysis.

Human Health Benefits of Reducing Fine Particulate Matter and Ozone (2020)

- Reductions in $PM_{2.5}$ and ozone[1] under Clear Skies would improve public health. By 2020, Americans would annually experience approximately;
  - 11,900 fewer premature deaths;
    - An alternative estimate projects 7,200 fewer premature deaths.[2]
  - 7,400 fewer cases of chronic bronchitis;
  - 11,900 fewer hospitalizations/emergency room visits for cardiovascular and respiratory symptoms; and
  - 15 million fewer days with respiratory illnesses and symptoms, including work loss days, restricted activity days, and days with asthma attacks
- The monetized benefits of the Clear Skies Act would total approximately $96 billion annually in 2020. This includes:
  - $93 billion dollars in health benefits.
    - An alternative estimate projects annual health benefits of $11 billion.[2]
  - $3 billion in benefits from improving visibility at select National Parks and Wilderness Areas. Note that visibility benefits would likely increase if emissions reductions under the WRAP were included in this analysis.
- Many additional, unquantified health benefits, including the benefits of reduced exposure to mercury, would also occur under 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 preliminary findings from the Health Effects Institute, the magnitude of mortality from short-tern 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 *Technical Addendum: Methodologies for Benefit Analysis of the Clear Skies Act, 2002*.

Human Health Benefits of Reducing Fine Particulate Matter and Ozone (2010)

- The Clear Skies Act would result in substantial **early** human health and visibility benefits due to reductions in $PM_{2.5}$ and ozone.
- By 2010, Americans would annually experience approximately:
  - 6,400 fewer premature deaths;
    - An alternative estimate projects 3,800 fewer premature deaths;[1]
  - 3,900 fewer cases of chronic bronchitis;
  - 6,300 fewer hospitalizations/emergency room visits for cardiovascular and respiratory symptoms; and
  - 8 million fewer days with respiratory illnesses and symptoms, including work loss days, restricted activity days, and days with asthma attacks.
- The monetized benefits of the Clear Skies Act would total approximately $44 billion annually in 2010. This would include:
  - $43 billion dollars in health benefits.
    - An alternative estimate projects annual health benefits of $5 billion.[1]
  - $1 billion in benefits from improving visibility at select National Parks and Wilderness Areas. Note that visibility benefits would likely increase if emissions reductions under the WRAP were included in this analysis.
- Many additional, unquantified health benefits, including the benefits of reduced exposure to mercury, would also occur under Clear Skies.

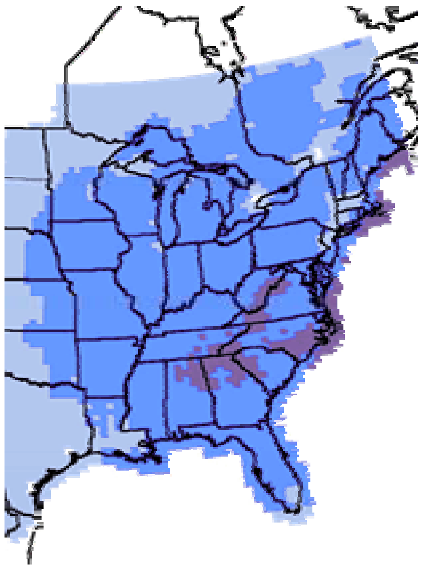
[1] The two sets of estimates reflect alternative assumptions and analytical approaches regarding quantifying and evaluating the effects of airborne particles on public health. All estimates assume that particles are causally associated with health effects, and that all components have the same toxicity. 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 preliminary findings from the Health Effects Institute, the magnitude of mortality from short-tern 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 *Technical Addendum: Methodologies for Benefit Analysis of the Clear Skies Act, 2002*.

Fine Particles in the Air Decrease Visibility

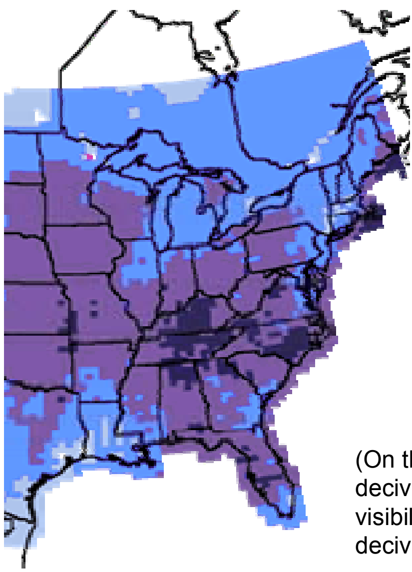
- SO_2 and NOx emissions form sulfate and nitrate particles in the atmosphere that can be transported many miles downwind from emissions sources.
- Fine particles (including sulfates and nitrates) in the air scatter light and create hazy conditions, decreasing visibility. Decreased visibility is sometimes 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 by as much as 80% to 10 miles or less on the haziest days in some National Parks;
  - Impaired urban vistas nationwide.
- In the western U.S.:
  - 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 eastern U.S.:
  - 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 (2020)

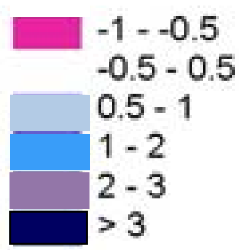
Deciview Change 2020 Base Case vs. Clear Skies



Deciview Change 1996 vs. 2020 with Clear Skies



Deciview Improvement



(On these maps, a positive change in deciviews is an improvement in visibility; a negative change in deciviews is a decrease in visibility.)

- Clear Skies would improve visibility over much of the East and Midwest 1-2 deciviews beyond what is expected under the Base Case in 2020.
  - The greatest improvements (2-3 deciviews) are projected along the Appalachians, including the Blue Ridge and Great Smoky Mountains - areas where visibility has been deteriorating.
- Under Clear Skies and existing programs, visibility in a large portion of the East and Midwest would improve 2-3 deciviews from current levels.
  - Visibility along the southern Appalachian Mountains would improve more than 3 deciviews.
- Under Clear Skies, the Western Regional Air Partnership agreement will be honored and the emissions reductions are expected to take effect.
  - This will allow future growth in the West to occur without degrading visibility.
- The EPA is also considering other actions, such as the non-road diesel rule, that will help reduce visibility-impairing fine particle concentrations throughout the western and eastern U.S.

Notes: Title IV reduced over 3 million tons of SO_2 between 1990 and 1996 that are not captured by the improvements shown on the map because the base year for the analysis was 1996.

Emissions from certain sources, such as mining and metals processing, are expected to increase in the future. These sources, which are not affected by Title IV or Clear Skies, contribute to increases in fine particle concentrations in certain areas (e.g. Northern Minnesota).

The western U.S. is not shown in these maps because the emissions reductions expected from the WRAP have not yet been included in the air quality modeling analysis.

Monetized Visibility Benefits

- This assessment projects benefits due to improvements in impaired visibility in National Parks and Wilderness areas in many Class I areas in the Southeast, Southwest, and California. Note that visibility benefits would likely increase if emissions reductions under the WRAP were included in this analysis.
- In these areas, Clear Skies would achieve approximately:
  - $0.9 billion in annual visibility benefits by 2010;
  - $2.8 billion in annual visibility benefits by 2020.
- This estimate includes benefits in Shenandoah National Park and Great Smoky National Park, two of the most heavily visited National Parks and areas where some of the greatest visibility improvements are expected under Clear Skies.
- 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.

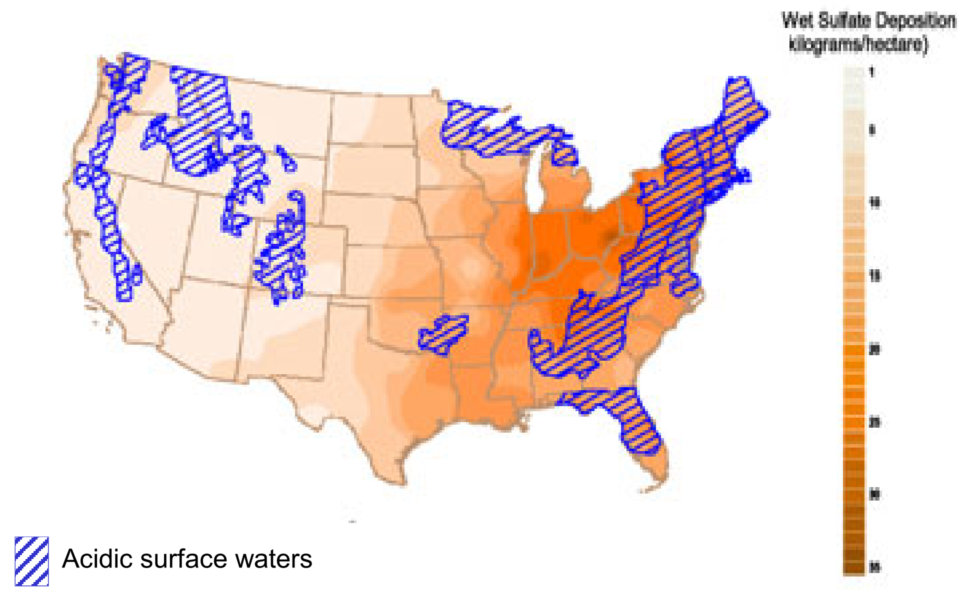
Visibility improves as the concentration of airborne fine particles declines. Based upon emissions reductions under Clear Skies, this analysis calculated changes in air quality and in visibility, measured in terms of deciviews. (A deciview is a standard measure of visibility change; a one or two deciview 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.

Left: Acadia National Park on a day with good visibility
Right: Acadia National Park on a day with poor visibility

How Does Acid Rain Damage 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

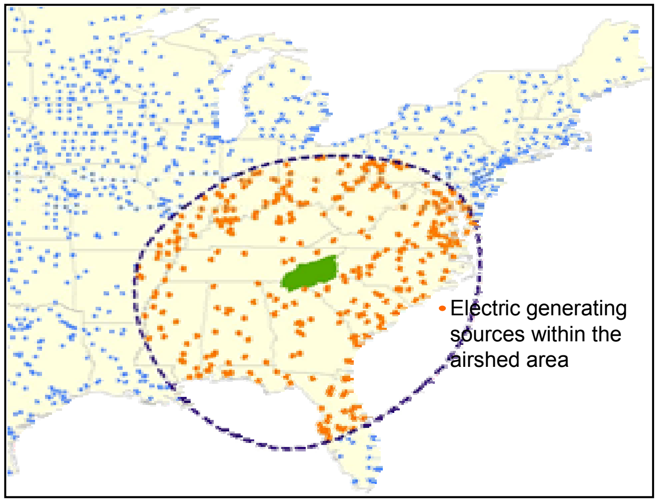


Source: CASTNet/NADP; National Surface Water Survey

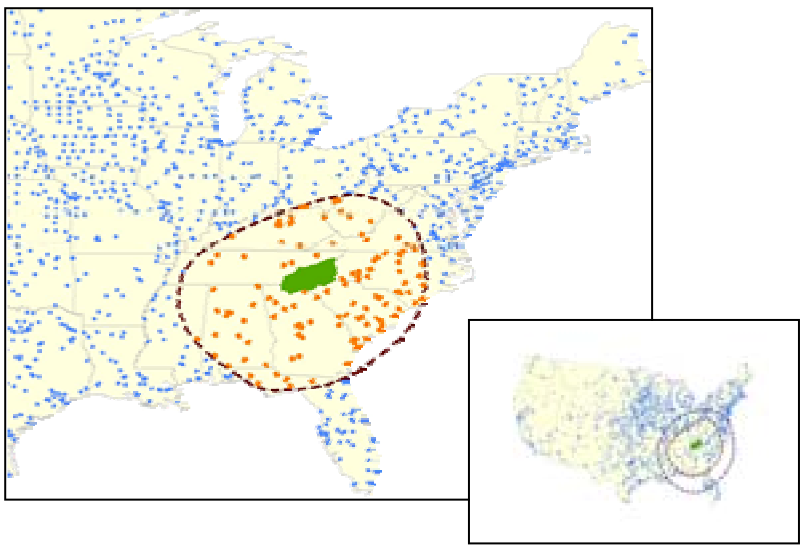
- Despite substantial emissions reductions over the last 20 years, high levels of sulfur and nitrogen deposition still enter acid-sensitive lakes and streams, leading to high levels of acidity.
- Southeastern streams would continue to grow **more** acidic without significant further reductions in sulfate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

Case Study of Emissions Changes: Southern Blue Ridge Mountains

Sulfur Airshed*

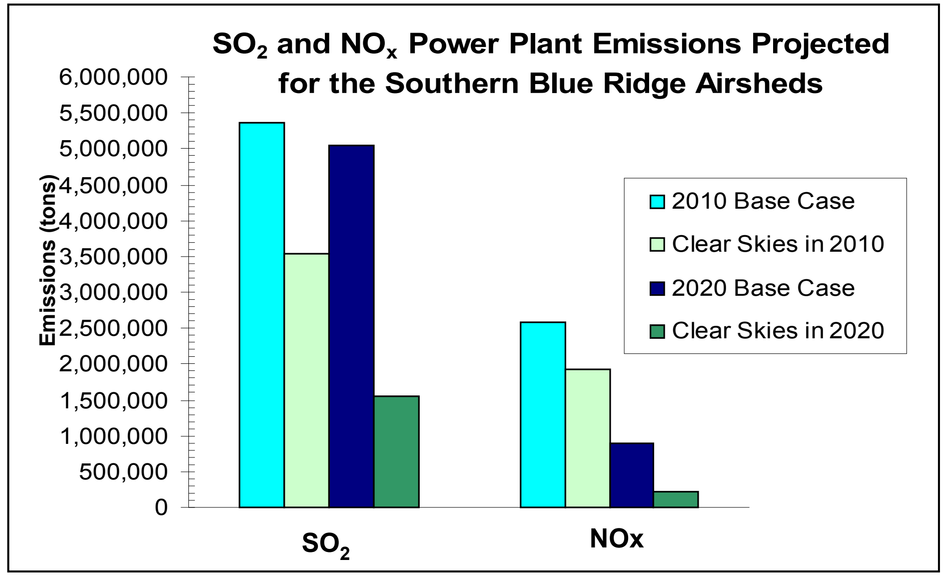


Nitrogen Airshed



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

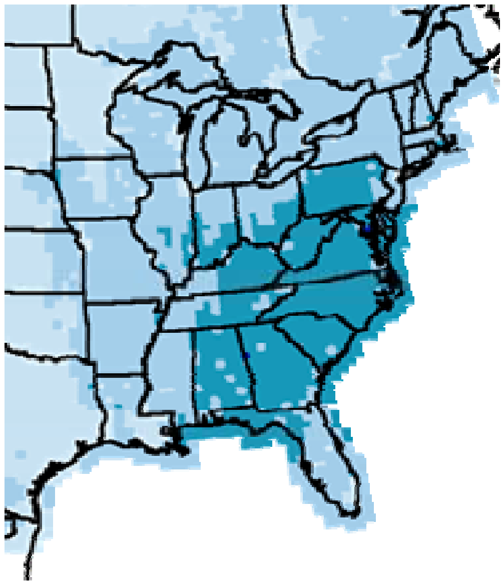
- This page shows regional airshed maps that were developed for the Southern Blue Ridge Mountains (which includes Great Smoky Mountain National Park).
- Multiple emission sources in numerous states contribute to air quality degradation and acid deposition in the Southern Blue Ridge region.



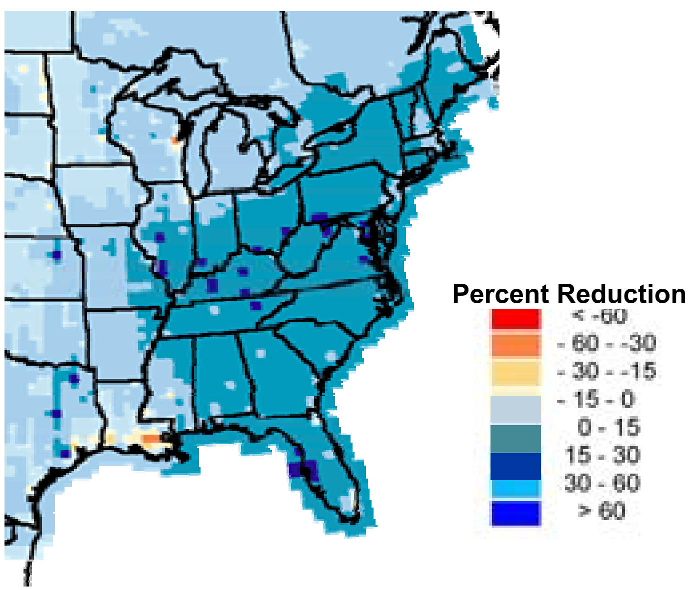
- Clear Skies is projected to result in a 34% reduction in SO_2 emissions and a 25% reduction in NOx emissions from power plants located in the airsheds in 2010, compared to the Base Case.
- In 2020, emission reductions from power plants in the Southern Blue Ridge region are projected to be substantially lower under Clear Skies than under the Base Case:
  - SO_2 emissions are projected to decrease 69%;
  - NOx emissions are projected to decrease 75%.

Sulfur Deposition (2020)

Percent Change 2020 Base Case vs. Clear Skies



Percent Change 1996 vs. 2020 with Clear Skies



- The upper map demonstrates that Clear Skies would achieve significant additional reductions of sulfur deposition of up to 60% beyond what is expected under the Base Case in 2020.
  - The greatest reductions would center on the Appalachian Mountains from central Pennsylvania to the southern Blue Ridge and across broad regions of the southeastern U.S.
  - Sensitive resources in the northeastern U.S., such as the Adirondack and Catskill Mountains, would experience reductions of 15-30%
- The lower map demonstrates that Clear Skies in combination with existing programs would contribute to significant reductions in sulfur deposition from current levels across much of the East.
  - Reductions of 30-60% would occur in sensitive resource areas of the Northeast, New England, and throughout the Appalachian Mountains.

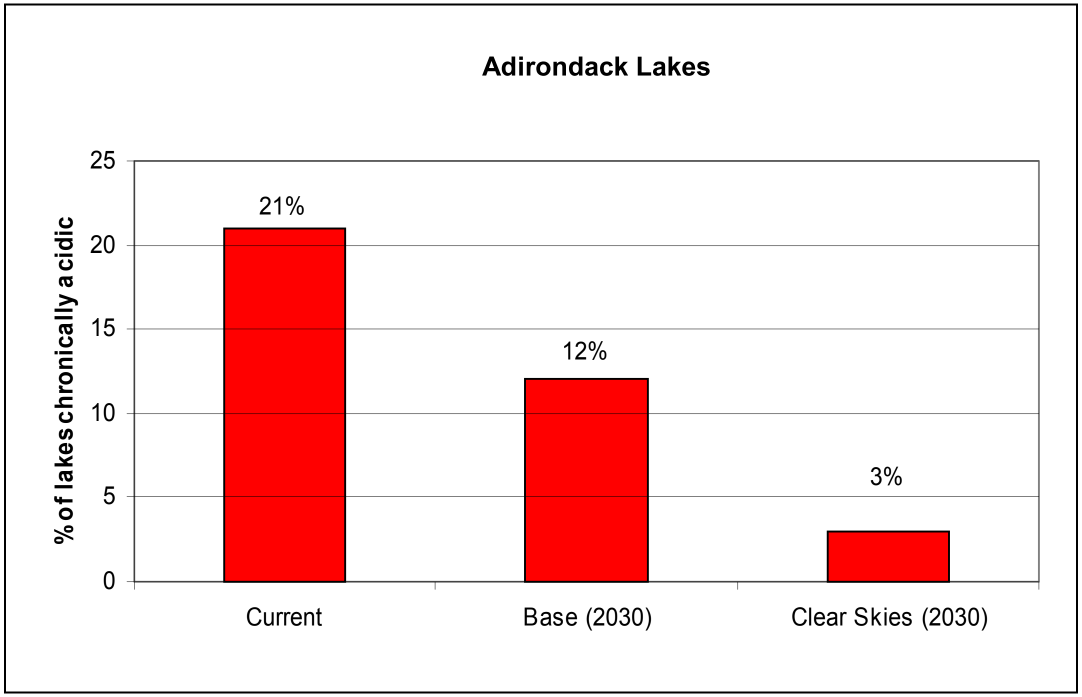
Notes: Title IV reduced over 3 million tons of SO_2 between 1990 and 1996 that are not captured by the improvements shown on the map because the base year for the analysis was 1996.

Emissions from certain sources, such as mining and metals processing and petroleum refining and chemical plants, are expected to increase in the future in some areas. These sources, which are not affected by Title IV or Clear Skies, contribute to increases in sulfur deposition in certain areas (e.g. Texas, Louisiana).

The western U.S. is not shown in these maps because the emissions reductions expected from the WRAP have not yet been included in the air quality modeling analysis.

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.*
- With Clear Skies, lake conditions would improve dramatically by 2030: only 3% of lakes would remain chronically acidic.*



- However, a significant proportion of Adirondack lakes would still become acidic periodically due to seasonal or storm events.

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

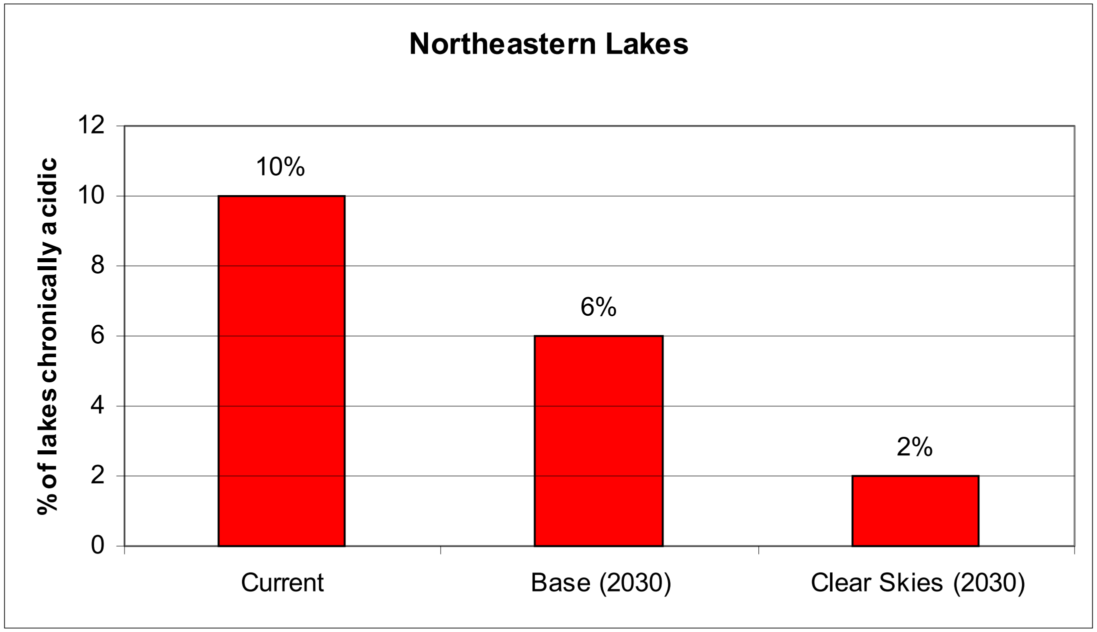
Reduced Acidity of Northeastern Lakes and Southeastern Streams

Northeast Region

- Lakes in the Northeast region (including Adirondack lakes) are both “direct” and “delayed response” systems; some lakes may not completely respond to the deposition changes considered here by 2030.
- 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 existing programs, 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.

Impacts of Reductions in Sulfur Deposition on Acid-Sensitive Lakes and Streams

		Current	Base Case (2030)	Clear Skies (2030)
	Northeastern Lakes			
	chronically acidic	10%	6%	2%
	episodically acidic	21%	25%	28%
	non-acidic	69%	69%	70%
	Adirondack Lakes			
	chronically acidic	21%	12%	3%
	episodically acidic	43%	52%	61%
	non-acidic	36%	36%	36%
	Southeastern Streams			
	chronically acidic	17%	17%	17%
	episodically acidic	19%	27%	25%
	non-acidic	64%	56%	58%

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, waters first become episodically acidic (ANC of 0-50 μeq/l) and finally non-acidic (ANC > 50). However, waters can also become more acidic if acid deposition increases.
- 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 deterioration of stream health expected under the Base Case.

The Road to Recovery

Chronically acidic water
water acidic all the time; sensitive plants and animals cannot survive

Episodically acidic water
significant recovery but water still acidified seasonally or after storms

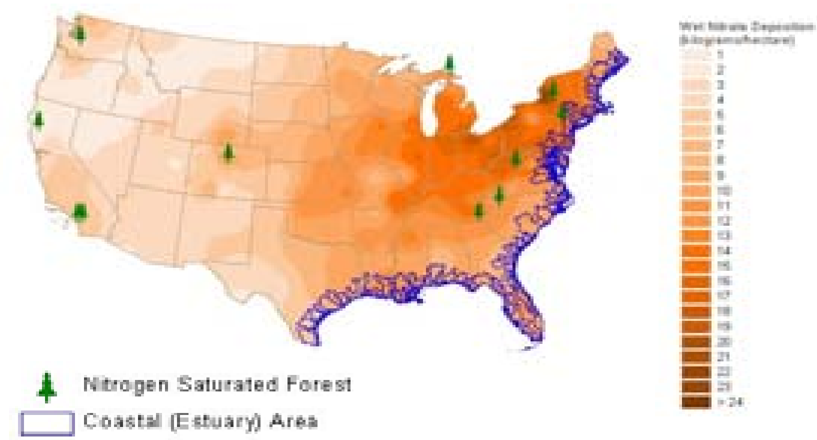
Non-acidic water
complete recovery of water chemistry; even sensitive plants and animals can survive

How Does Nitrogen Deposition Harm Forests and Coastal Ecosystems?

- NOx emissions from power plants contribute significant amounts of nitrogen to coastal waters and affected 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 declines in 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).

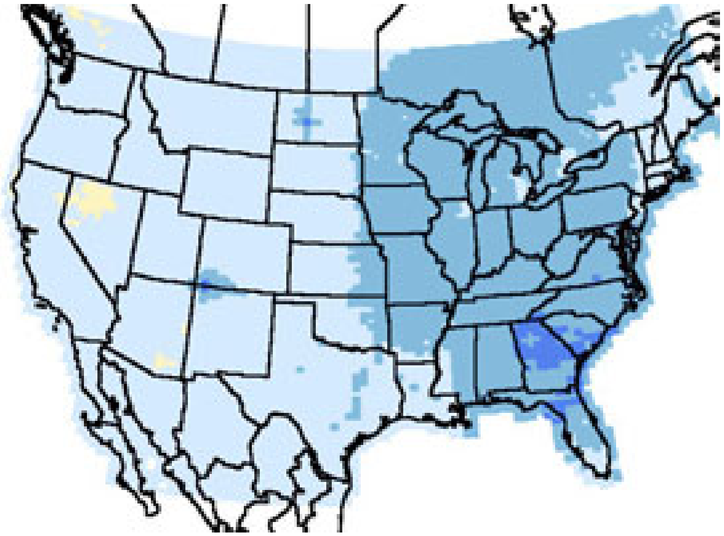
Annual Wet Nitrate Deposition to Sensitive Resources



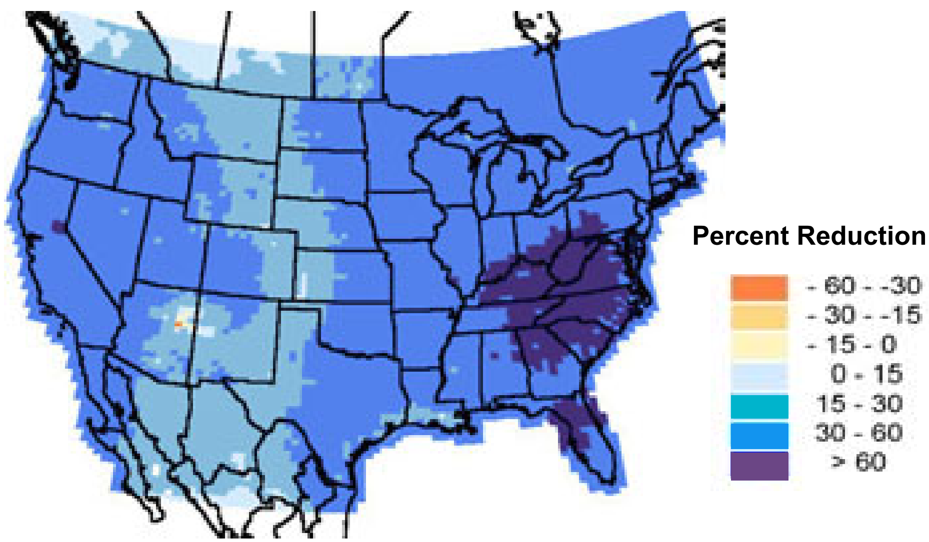
Deposition data measured by CASTNet and NADP, 1997-1999

Nitrogen Deposition (2020)

Percent Change 2020 Base Case vs. Clear Skies



Percent Change 1996 vs. 2020 with Clear Skies

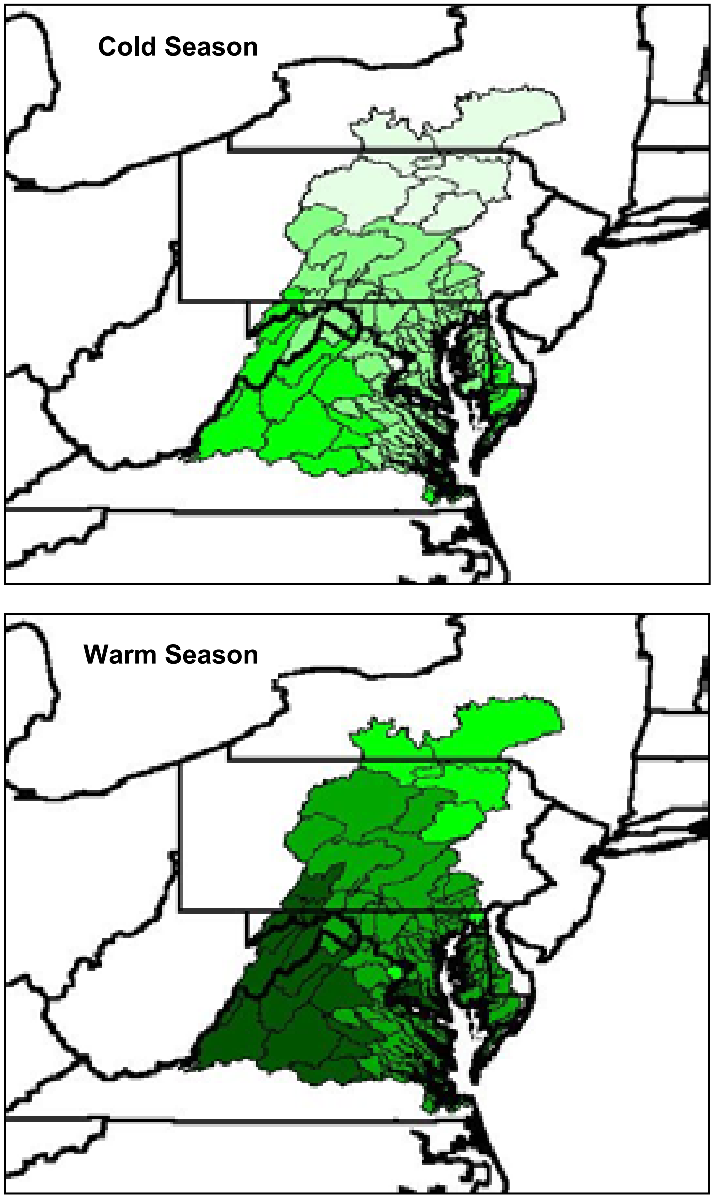


- The upper map demonstrates that Clear Skies would achieve significant additional reductions of nitrogen deposition of 15-30% across much of the East beyond what is expected under the Base Case.
  - The greatest reductions of 30-60% would center on the southeastern portions of the Appalachian Mountains, including Great Smoky Mountain National Park.
  - Sensitive resources in the northeastern U.S., such as the Adirondack and Catskill Mountains, would experience reductions of up to 30%.
- The lower map demonstrates that Clear Skies and existing programs would reduce nitrogen deposition in the Southeast and mid-Atlantic by 60% or more from current levels.
- 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 increase in nitrogen deposition at a location in Arizona is the result of a significant increase in utilization from the baseline at a power generating facility in that state. This increase is an artifact of the baseline year choice (because this baseload facility was only partially utilized in 1996), and would not have otherwise appeared as an increase.

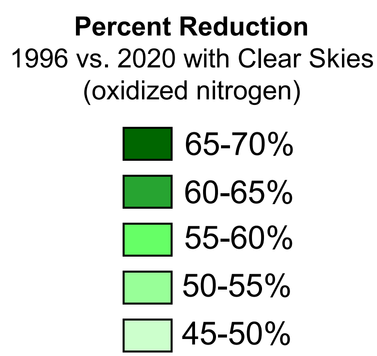
Nitrogen Deposition to the Chesapeake Bay Watershed (2020)

Percent Change 1996 vs. 2020 with Clear Skies

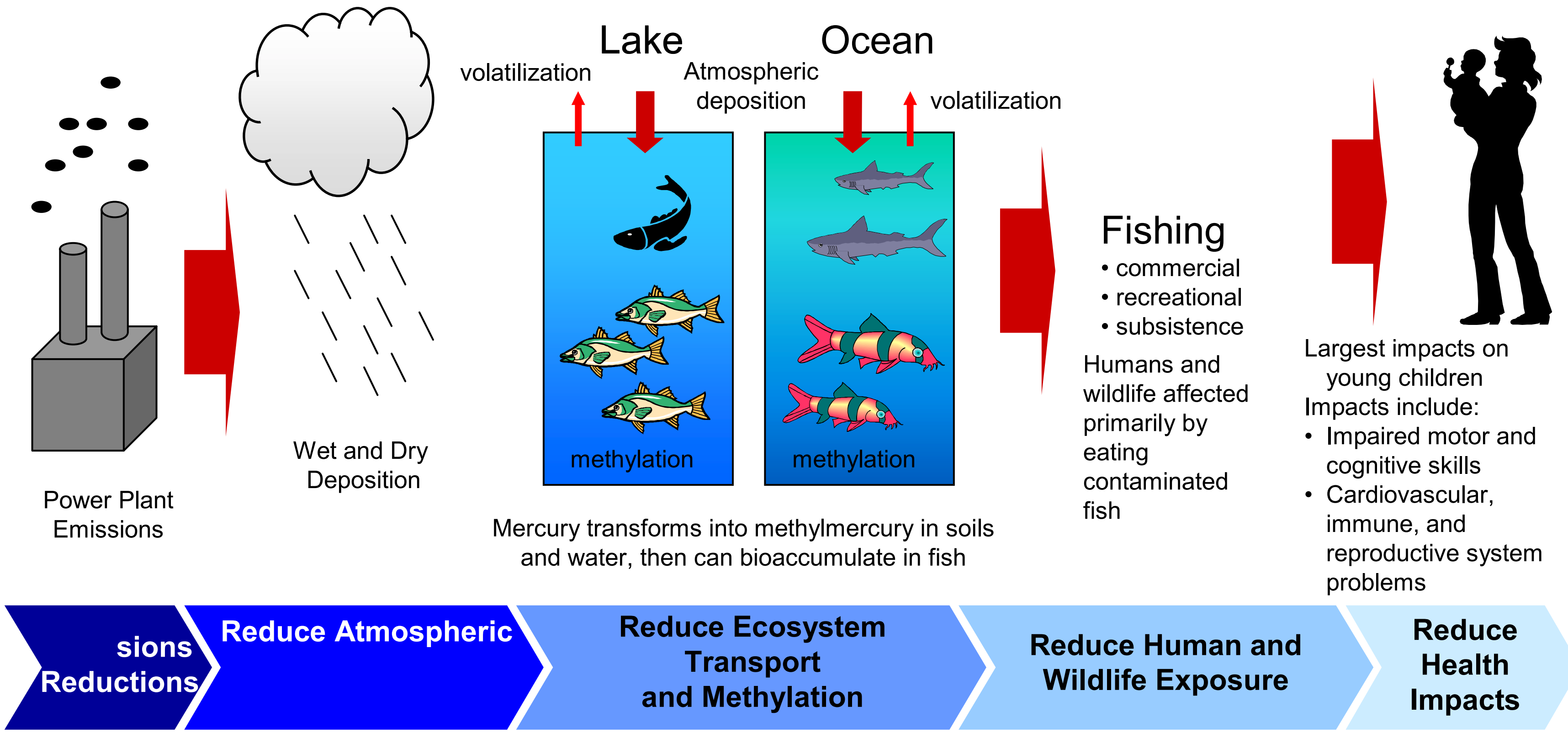


- Under the Clear Skies Act, in 2020, oxidized nitrogen deposition to the Chesapeake Bay watershed would be reduced by more than 50% from current levels.

- Reductions in oxidized nitrogen deposition would be greatest during the warm season, ranging from 50-70% across much of the watershed.



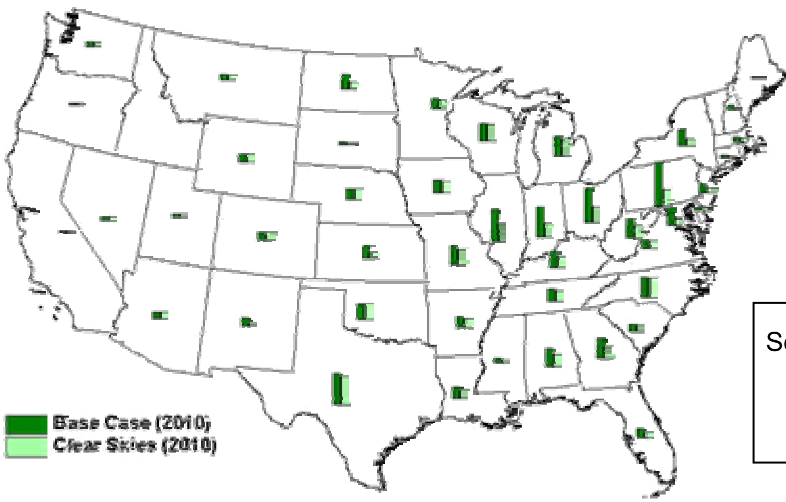
Mercury Emissions from Power Plants Contaminate Fish



- By 2020, Clear Skies implementation will double the use of scrubber technology, meaning that approximately 67% of power generation capacity under Clear Skies will 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 50% 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.
- 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.

State-By-State Mercury Emissions

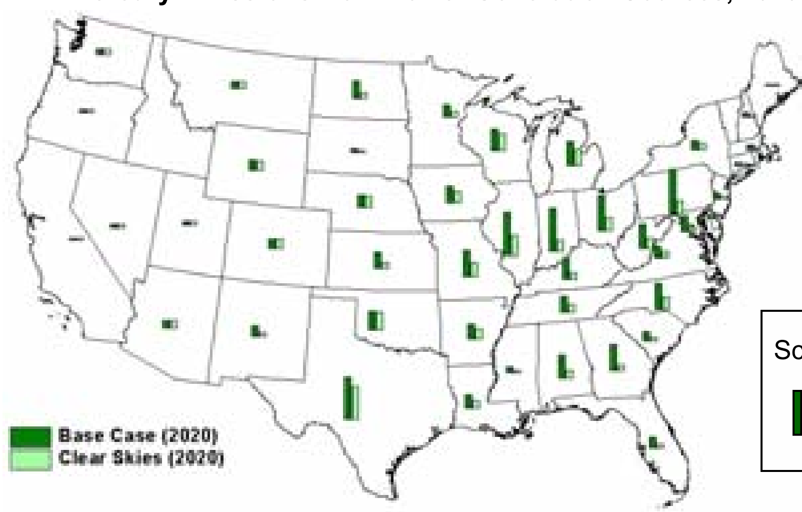
Mercury Emissions from Power Generation Sources, 2010



Scale:

= approximately 3.3 tons

Mercury Emissions from Power Generation Sources, 2020



Scale:

= approximately 2.6 tons

- The trading provisions included in Clear Skies do not result in mercury emissions increases in any state.

Notes: While state-level emissions decrease, emissions may increase at specific sources in some states. Total emissions under Clear Skies in 2010 would be 26 tons; total emission under Clear Skies in 2020 would be 18 tons.

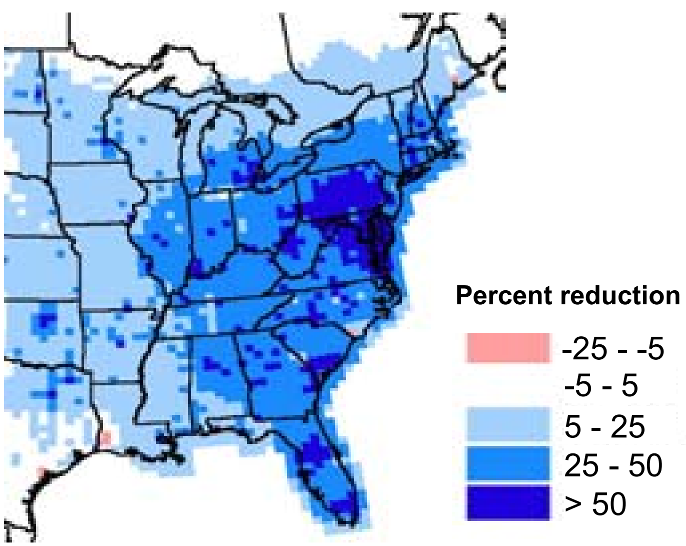
Emissions are from coal-fired electric generating facilities greater than 25MW.

The EPA Base Case does not include any potential future regulations under the CAA to reduce mercury from power plants.

Mercury Deposition (2020)

Percent Change 2020 Base Case vs. Clear Skies

Percent Change 1996 vs. 2020 with Clear Skies



- The top map demonstrates that Clear Skies would achieve significant additional reductions of up to 25% across much of the East beyond what is expected under the Base Case.
  - The greatest reductions of up to 50% would occur along the Ohio River, in portions of the mid-Atlantic region, and in northern sections of Georgia and Alabama.
- The lower map indicates the large reductions in mercury deposition expected from Clear Skies in addition to those expected from recently-implemented programs, including the municipal waste combustor and medical waste incinerator MACT standards.
  - Many areas would see large decreases in mercury deposition of more than 50%, including the mid-Atlantic, many parts of the Southeast and Northeast, and southeastern Michigan.

Notes: The small increase in mercury deposition at one location in the top map is attributable to a single facility mistakenly omitted from the Clear Skies mercury cap in the IPM analysis. Were this facility included in the cap, this increase would not have occurred. The increases in in the lower map are due to increases in emissions from sources that are not affected by the Clear Skies Act.

The western U.S. is not shown in these maps because the emissions reductions expected from the WRAP have not been included in the air quality modeling analysis.