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Second Prospective Ecological Benefits Analysis of the Clean Air Act Amendments: EES Briefing of January 2010 Draft Report

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Acknowledgements

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Briefing Outline

- Background
- Outline of the Ecological Report
- Overview of Updated Literature Review
- Maps Highlighting Distribution of Pollutants across the U.S.
- Summary of Acidification Case Studies
  - Recreational Fishing
  - Commercial Timber
- Summary of Ozone Effects Analysis
  - Timber and Agricultural Production

Background

- May 2003 – EPA releases analytic plan for second prospective analysis.
- November 2004 – EES meeting to discuss Analytic Plan review.
- June 2005 – EES releases advisory on plans for the second prospective analysis.
  - Supportive of EPA's plans for: a) a qualitative characterization of the ecological effects of CAA-related air pollutants throughout the country; b) expanded literature review; and c) a quantitative ecosystem-level case study of ecological service benefits.
  - Recommended addition of an upland case study site, suggested potential case study sites (including the Adirondacks).

Outline of the Ecological Benefits Assessment

Ecological Benefits Report

- Chapter 1 – Introduction
- Chapter 2 – Literature Review
- Chapter 3 – Air Pollutants in Sensitive Ecosystems
- Chapter 4 – Adirondack Recreational Fishing Case Study (lake acidification)
- Chapter 5 – Adirondack Timber Case Study (soil acidification)

Health and Welfare Benefits Report

- Chapter 4 – Commercial Agriculture and Forestry Effects (Ozone)

Updated Literature Review: Effects of Air Pollutants on Ecological Resources

- Scope limited to:
  - Pollutants regulated by the CAAA
  - Known effects of pollutants on natural systems as documented in peer reviewed literature
- Effects of air pollutants on ecological endpoints, focusing on:
  - Acidic deposition
  - Nitrogen deposition
  - Mercury
  - Tropospheric ozone
- Discussion includes tables for each pollutant class, detailing ecological effects by level of biological organization.

Literature Review Summary

POLLUTANT CLASS	MAJOR POLLUTANTS AND PRECURSORS	ACUTE EFFECTS	LONG-TERM EFFECTS
Acidic deposition	Sulfuric acid, nitric acid Precursors: Sulfur dioxide, nitrogen oxides	Direct toxic effects to plant leaves and aquatic organisms.	Progressive deterioration of soil quality due to nutrient leaching. Forest health decline. Acidification of surface waters. Reduction in acid neutralizing capacity in lakes and streams. Enhancement of bioavailability of toxic metals
Nitrogen Deposition	Nitrogen compounds (e.g., nitrogen oxides)	N/A	Nitrogen saturation of terrestrial ecosystems, causing nutrient imbalances and reduced forest health. Soil and water acidification. Reduction in acid neutralizing capacity in lakes and streams. Progressive nitrogen enrichment of coastal estuaries causing eutrophication. Changes in the global nitrogen cycle.
Ozone	Tropospheric ozone Precursors: Nitrogen oxides and volatile organic compounds (VOCs)	Direct toxic effects to plants.	Alterations of ecosystem wide patterns of energy flow and nutrient cycling; community changes.
Hazardous Air Pollutants (HAPs)	Mercury, dioxins	Direct toxic effects to animals.	Conservation of mercury and dioxins in biogeochemical cycles and accumulation in the food chain. Sublethal impacts.

Effects of Nitrogen Deposition on Natural Systems at Various Levels of Organization

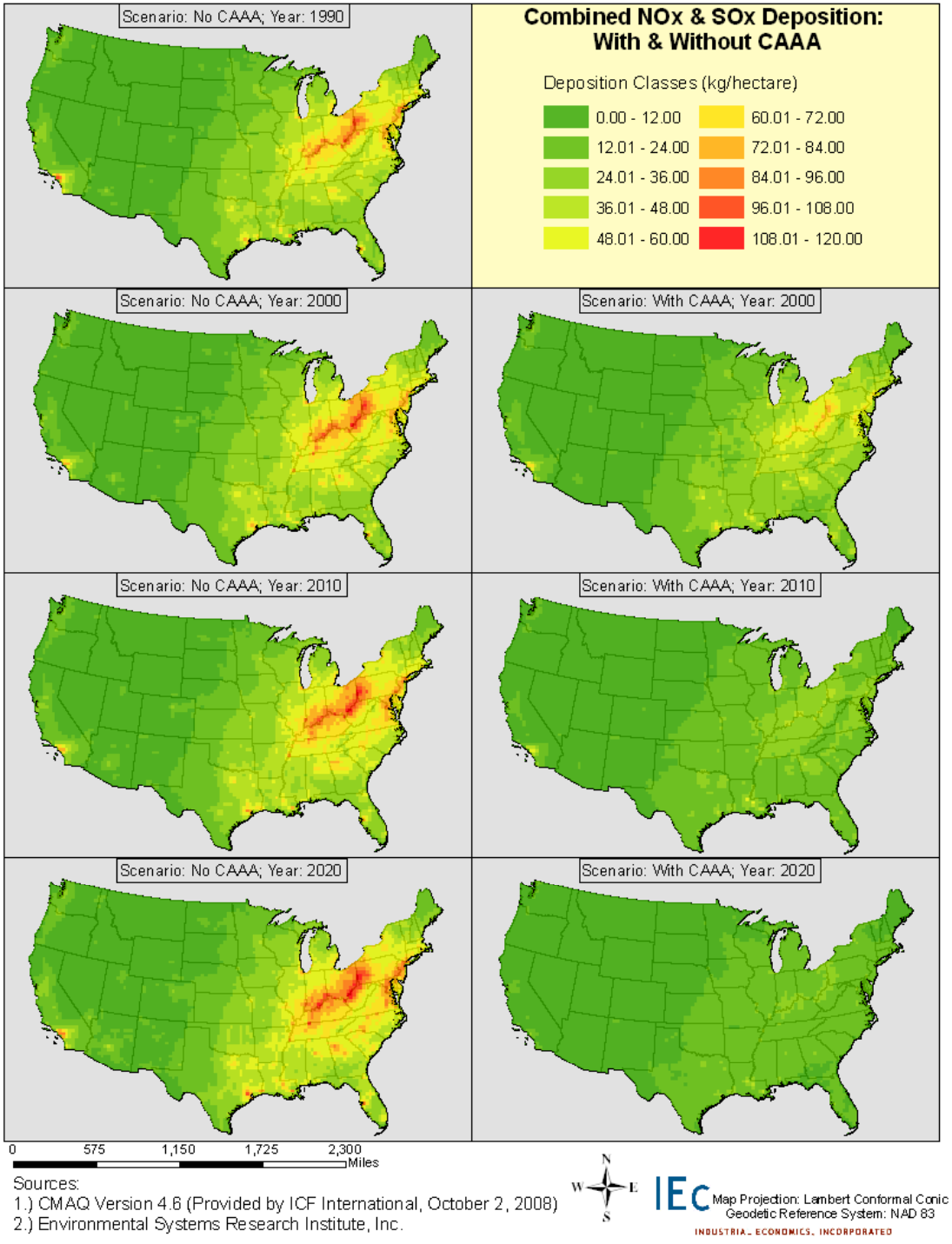
SPATIAL SCALE	TYPE OF INTERACTION	EXAMPLES OF EFFECTS		EXAMPLE REFERENCES
		FOREST ECOSYSTEMS	ESTUARINE ECOSYSTEMS	
Molecular and cellular	Chemical and biochemical processes.	Increased uptake of nitrogen by plants and microorganisms. With chronic exposure, reduced stomatal activity and photosynthesis in some species.	Increased assimilation of nitrogen by marine plants, macroalgae, and microorganisms.	4, 8, 14, 17, 37, 38
Individual	Direct physiological response.	Increases in leaf- size of terrestrial plants. Increase in foliar nitrogen concentration in major canopy trees. Change in carbon allocation to various plant tissues.	Increase in algal growth.	4, 13, 25, 26, 27, 29, 37, 40
	Indirect effects: Response to altered environmental factors or alterations of the individual's ability to cope with other kinds of stress.	Decreased resistance to biotic and abiotic stress factors including pathogens, insects, and frost. Disruption of plant-symbiont relationships with mycorrhizal fungi.	Injuries to marine fauna through depletion of oxygen in the water column. Loss of physical habitat due to increased macroalgal biomass and loss of seagrass beds. Injury and habitat loss through increased shading by macroalgae.	9, 25, 26, 27, 37
Population	Change of population characteristics like productivity or mortality rates.	Increase in biological productivity and growth rates of some species. Increase in pathogens.	Increase in algal and macroalgal biomass.	5, 6, 8, 15, 16, 17, 18, 20, 22, 37, 42
Community	Changes of community structure and competitive patterns.	Alteration of competitive patterns. Selective advantage for fast growing species and individuals that efficiently use additional nitrogen. Loss of species adapted to nitrogen-poor or acidic environments. Increase in weedy species or parasites.	Excessive algal growth. Changes in species composition with increase in algal and macroalgal species and decrease or loss of seagrass beds. Loss of species sensitive to low oxygen conditions.	5, 8, 18, 22, 24, 27, 29, 33, 34, 35, 39
Local Ecosystem (*e.g.*, landscape element)	Changes in nutrient cycle, hydrological cycle, and energy flow of lakes, wetlands, forests, grasslands, etc.	Changes in the nitrogen cycle. Progressive nitrogen saturation. Mobilization of nitrate and aluminum in soils. Loss of calcium and magnesium from soil. Change in organic matter decomposition rate.	Changes in the nitrogen cycle. Increased algal growth leading to depletion of oxygen, increased shading of seagrasses. Reduced water clarity and dissolved oxygen levels.	1, 3, 14, 15, 16, 18, 19, 21, 22, 23, 25, 26, 27, 28, 30, 33, 35
Regional Ecosystem (*e.g.*, watershed)	Changes in biogeochemical cycles within a watershed. Region-wide alterations of biodiversity.	Leaching of nitrate and aluminum from terrestrial sites to streams and lakes. Acidification of soils and waterbodies. Increased emission of greenhouse gases from soils to atmosphere. Change in nutrient turnover and soil formation rates.	Additional input of nitrogen from nitrogen-saturated terrestrial sites within the watershed. Regional decline in water quality in waterbodies draining large watersheds (e.g. Chesapeake Bay). Changes in the regional-scale nitrogen cycle.	7, 10, 11, 12, 10, 11, 12, 15, 16, 18, 21, 22, 25, 26, 27, 30, 32, 33, 35, 43
Global Ecological System	Changes in global biogeochemical cycles; increased availability of reactive nitrogen to plants.	Increased input of reactive nitrogen; loss of soil nutrients. Nitrogen saturation and leaching throughout forests in northeastern United States and Western Europe. Acidification of surface waters.	Greatly increased transfer of nitrogen to coastal ecosystems; change in structure and function of estuarine and nearshore systems.	41, 42, 43, 44

Distribution of Air Pollutants

- Maps present the distribution of the three air pollutant classes (acidic deposition, nitrogen deposition, and ozone concentration) across the conterminous U.S.
- Acidic and nitrogen deposition maps present estimates for 36-km^2 grid cells generated using CMAQ Version 4.6.
- Tropospheric ozone concentration maps present estimates for 12-km^2 grid cells.
- All maps display data for both baseline (with CAAA) and counterfactual (no CAAA) scenarios in ten-year increments (1990—deposition data only, 2000, 2010, 2020).

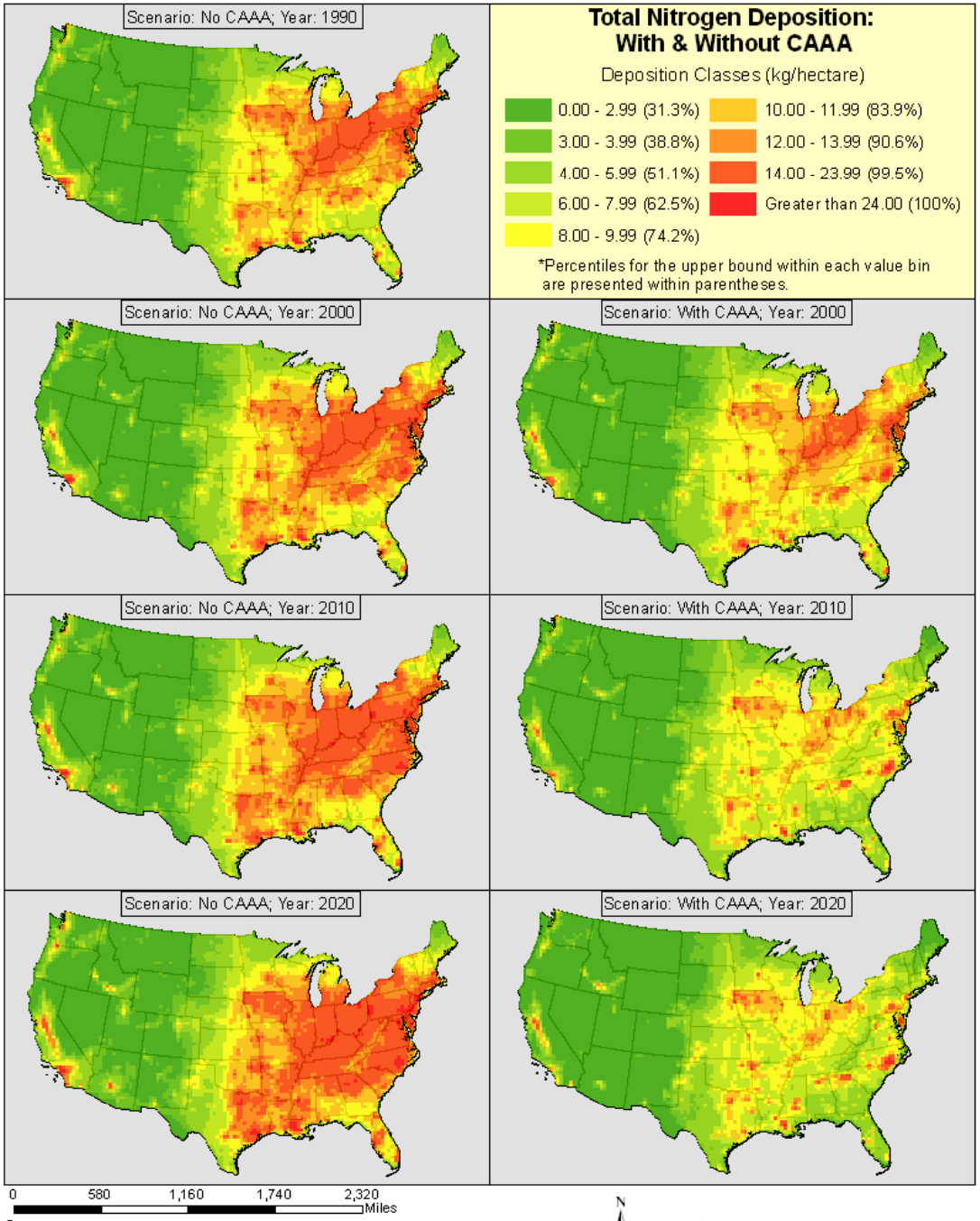
Acidic Deposition

- Greatest acidic deposition reduction in: the Ohio River Valley and Southeast.
- Acidic deposition "hot spots" in southern Louisiana and eastern Texas on the Gulf Coast.



Nitrogen Deposition

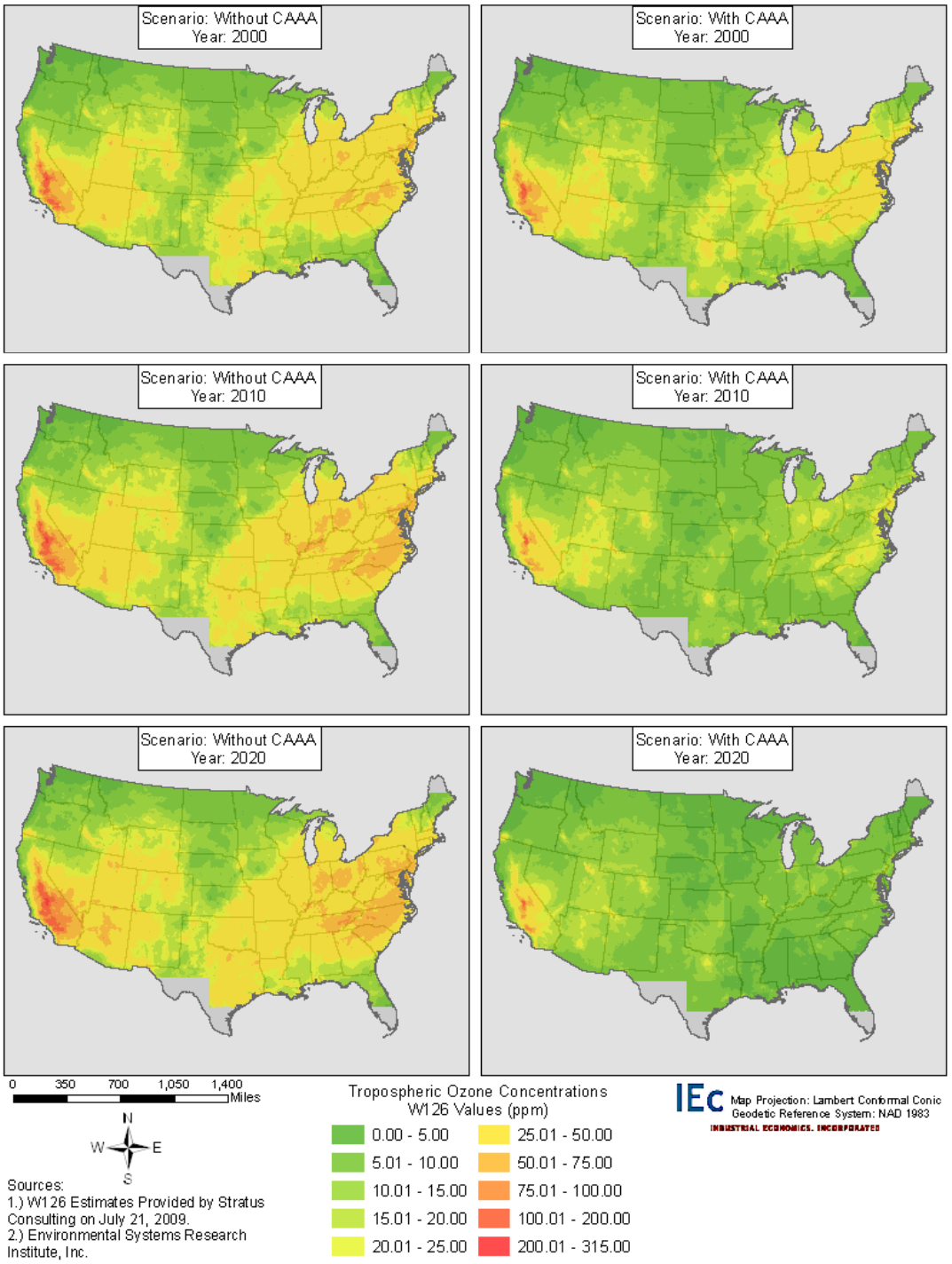
- Greatest nitrogen deposition reduction in: the Ohio River Valley, Southeast, and southern New England.
- Nitrogen deposition "hot spots" in southern Louisiana and eastern North Carolina.



Sources:
1.) CMAQ Version 4.6 (Provided by ICF International, October 2, 2008)
2.) Environmental Systems Research Institute, Inc.

Tropospheric Ozone

- Ozone estimates presented for May through September.
- Greatest ozone concentration reductions in: the Southwest, Corn Belt, Ohio River Valley, and mid-Atlantic states. Some substantial reductions in parts of California.
- Ozone concentration "hot spots" in southern California, central Ohio, eastern Tennessee, and portions of Virginia, North Carolina, and South Carolina.

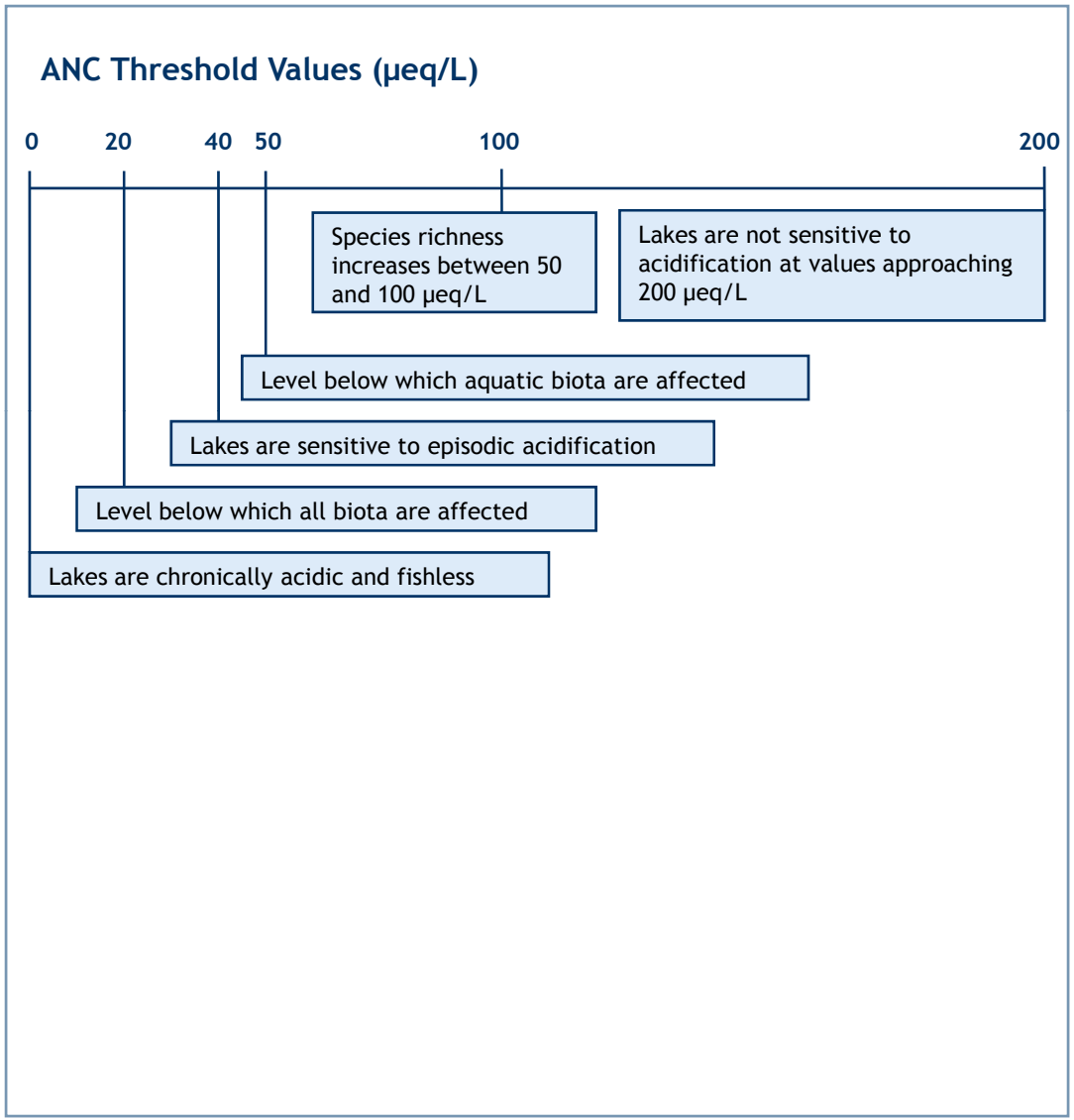


Adirondack Recreational Fishing Case Study: Overview

- Case study considers the economic benefit of reduced acidic deposition on the value of recreational fishing (i.e., willingness to pay) within the Adirondacks and New York State.

- Ecological model (MAGIC) forecasting ANC levels at sample lakes links to economic model (Montgomery-Needelman random utility model) forecasting resulting changes in consumer surplus.

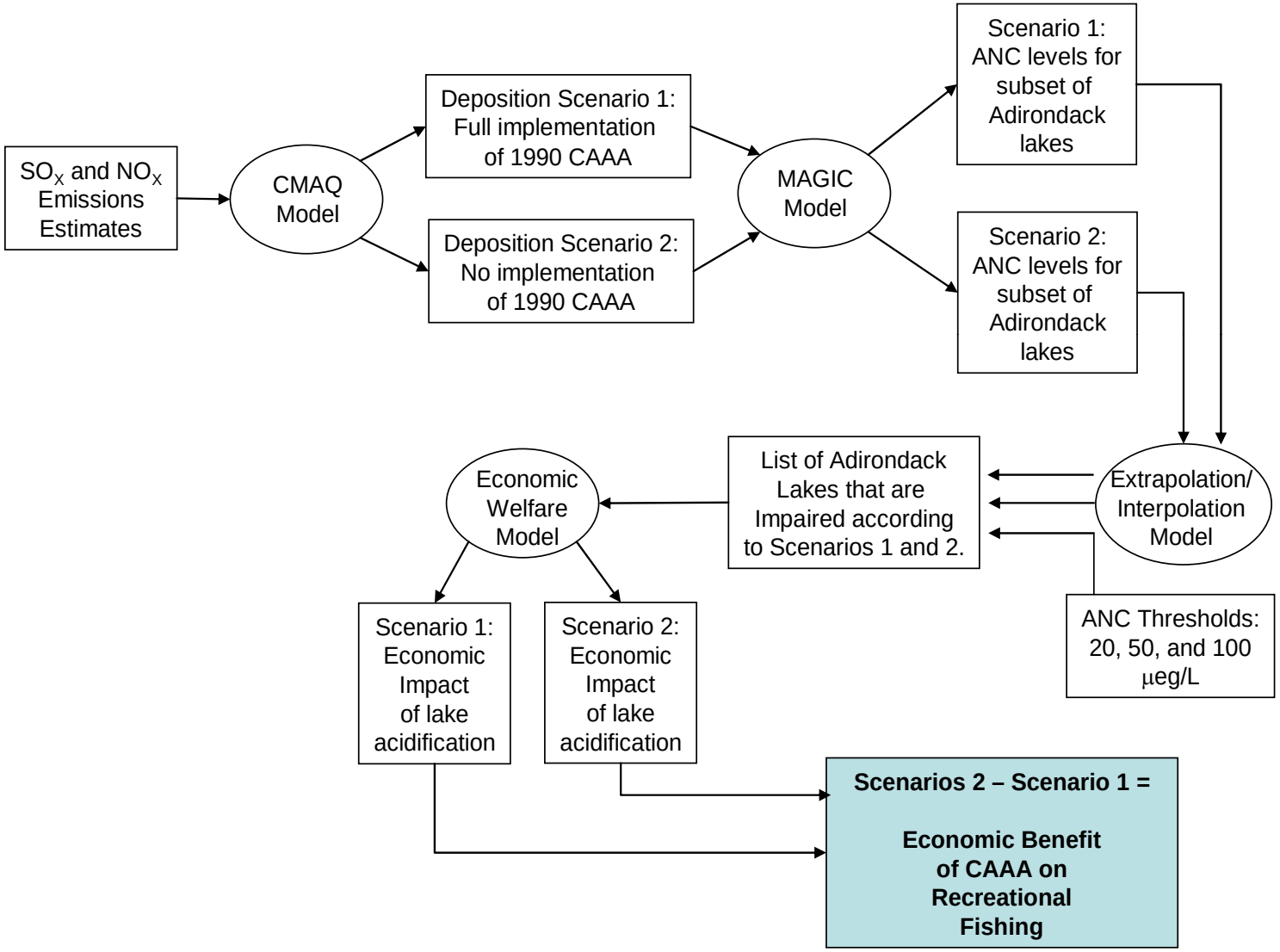
Adirondack Recreational Fishing Case Study: Overview



Lakes are classified as "fishable" (i.e., recreational fishing supported) or "impaired" (i.e., recreational fishing not supported) based on alternative assumed ANC thresholds:

- 20 µeq/L
- 50 µeq/L
- 100 µeq/L

Recreational Fishing Study: Conceptual Framework



Recreational Fishing Study: Results Summary

Results are presented two ways:

1. Forecast lake acidification only for Adirondack lakes. PV benefits range from **$180 million to $269 million** depending on ANC threshold assumption.

2. Forecast lake acidification for all New York State lakes (greater uncertainty). PV benefits range from **$529 million to $2.26 billion** depending on ANC threshold assumption.

PV Benefits (1990-2050), Adirondack Region:

ANC THRESHOLD (µeq/L)	PRESENT VALUE BENEFITS ($2006)
	FIVE PERCENT DISCOUNT RATE
20	$269 million
50	$248 million
100	$180 million

PV Benefits (1990-2050), New York State:

ANC THRESHOLD (µeq/L)	PRESENT VALUE BENEFITS ($2006)
	FIVE PERCENT DISCOUNT RATE
20	$529 million
50	$2.35 billion
100	$2.26 billion

Recreational Fishing Study: Key Uncertainties

The resulting benefits are mostly likely an underestimate:

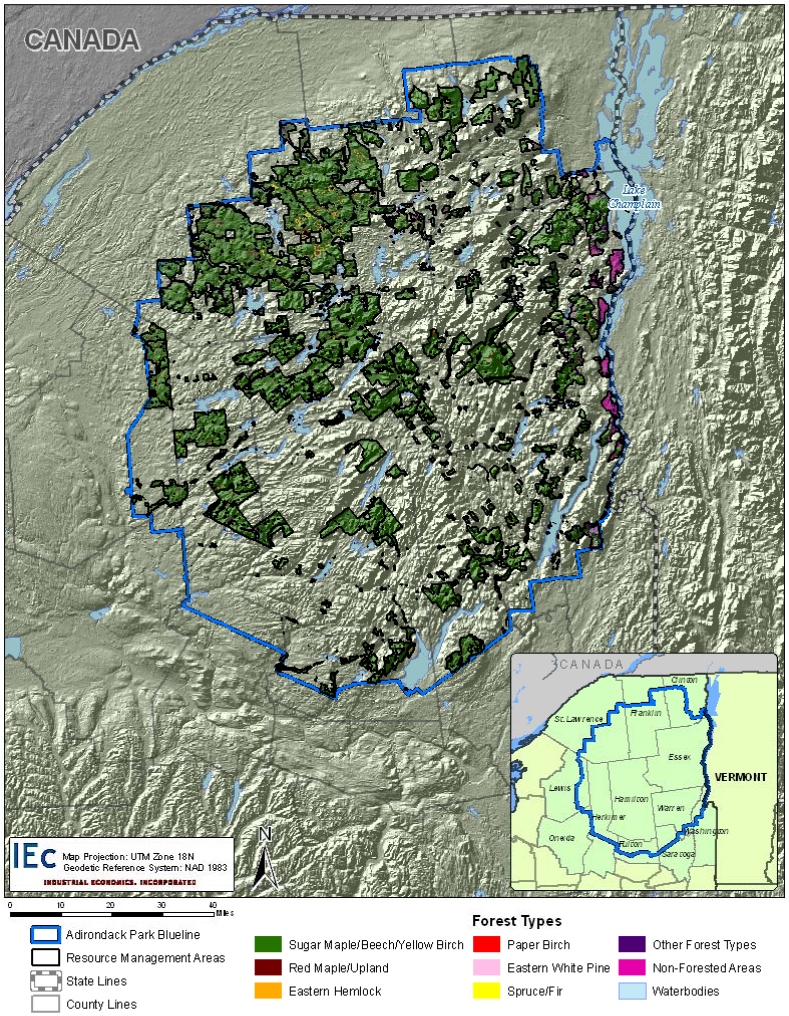
- Assumes level of impairment is binary (i.e., a lake is either fishable or not fishable) based on assumed threshold.
- Thresholds defining "fishability" are uncertain. Analysis applies three thresholds to test sensitivity.
- The RUM only considers the behavior of anglers taking single day trips. Overnight fishing trips are not included in the economic model.
- The RUM only considers the behavior of New York State residents. It is likely that people outside of New York also take day trips within New York for the purposes of recreational fishing.

Adirondack Timber Case Study: Overview

- Case study considers the effects of reduced soil acidity levels due to the CAAA on forest resources within Adirondack Park.
- Soil acidity levels are expressed in terms of percent base saturation.
- Benefits of the CAAA determined by estimating differences in percent base saturation levels with the CAAA versus without the CAAA and predicting the timber growth benefits associated with such differences.

Adirondack Timber Study: Industry Profile

Distribution of Forest Types in Resource Management Areas Within Adirondack Park



*Sources: 1.) U.S. Forest Service; 2.) N.Y. Dept. of Environmental Conservation; 3.) Environmental Systems Research Institute, Inc.

Average Stumpage Prices for Commonly Harvested Species, Weighted-Average Stumpage Price Across Species, Annual Harvest Volume, and Annual Harvest Value by Product Type for Adirondack Park

SPECIES	MEDIAN STUMPAGE VALUES	
	SAWTIMBER ($/MBF)	PULPWOOD/CHIP WOOD ($/CORD)
HARDWOODS		
Sugar Maple[a]	$400	$10
Black Cherry[a]	$400	$10
Yellow Birch[a]	$200	$10
Red Maple[a]	$150	$10
Aspen[a]	$60	$5
American Beech[a]	$40	$10
SOFTWOODS		
White Pine[a]	$100	$5
Spruces[a]	$95	$5
Eastern Hemlock[a]	$50	$10
Weighted-Average Across Species[b]	$150	$8.70
Annual Harvest Volumes[b]	100,000 MBF	620,690 Cords
Annual Harvest Value (Total)	**$15,000,000**	**$5,400,000**

Notes:

1. Prices reported are equal to the median stumpage price for the average price range of the species.
2. The average stumpage value for pulpwood/wood-chips of $3/ton is converted to price per cord applying a 2.90 tons to 1.00 cord conversion factor.
3. The annual harvest volume for pulpwood/wood-chips of 1.8 million green tons is converted to cords applying a 2.90 tons to 1.00 cord conversion factor.

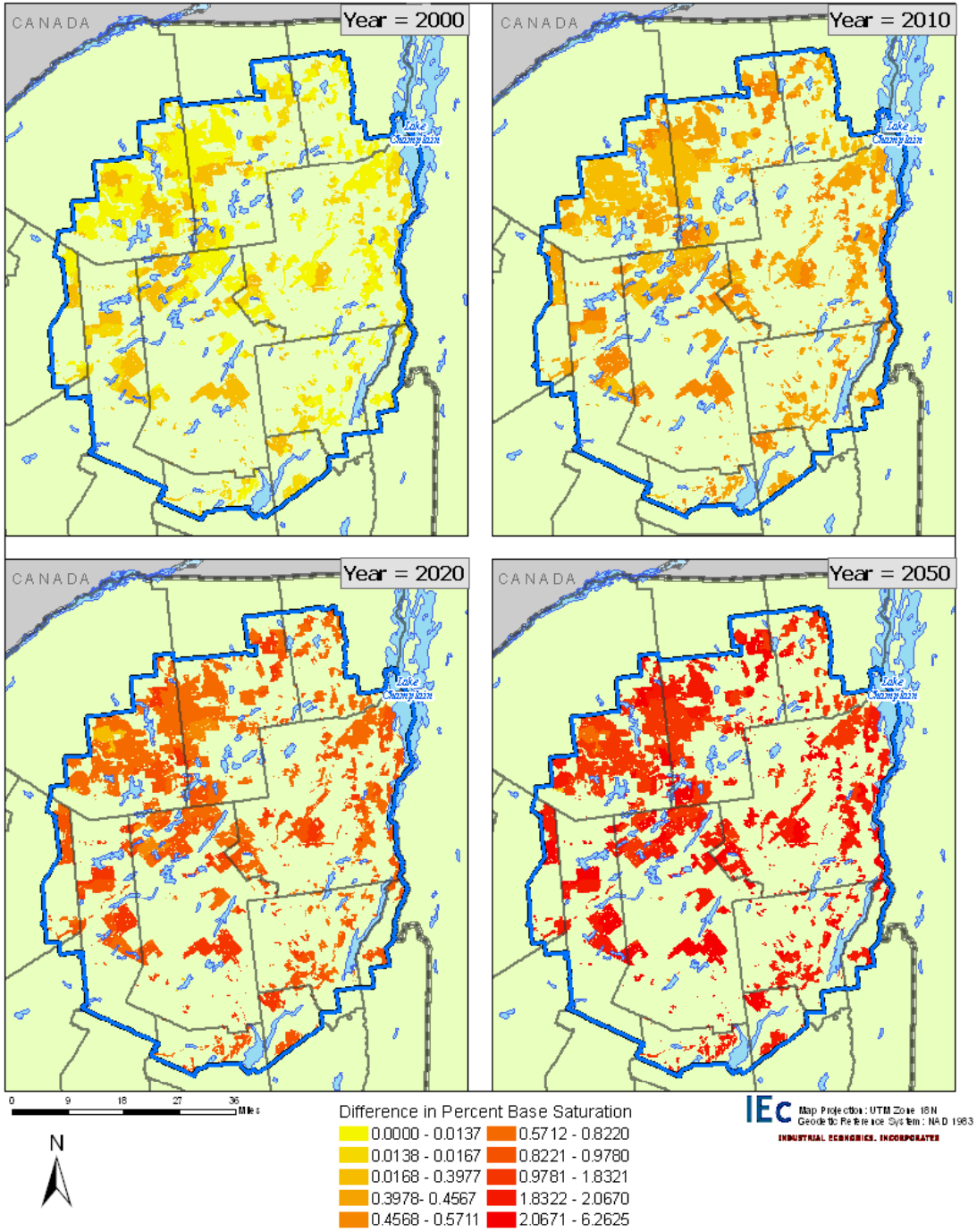
Sources:

[a] New York State Department of Environmental Conservation. 2009. Stumpage Price Report (Winter 2009/#74). New York State Department of Environmental Conservation, Division of Lands and Forests, Forest Utilization Program. Albany, New York.

[b] Average stumpage values across species and harvest volumes take into account harvest rates by species, as well as the quality of the wood harvested. Crawford, S. 2009. Personal communication on September 4, 2009 and September 15, 2009. New York State Department of Environmental Conservation, Division of Lands and Forests, Forest Utilization Program.

Differences in Percent Base Saturation Levels With and Without the CAAA in Forested Resource Management Areas

- Percent base saturation levels were estimated using MAGIC for a subset of HUCs.
- Percent base saturation levels for 33 12-digit HUCs were extrapolated applying a multiple linear regression model to the remaining 282 12-digit HUCs intersecting the Park.



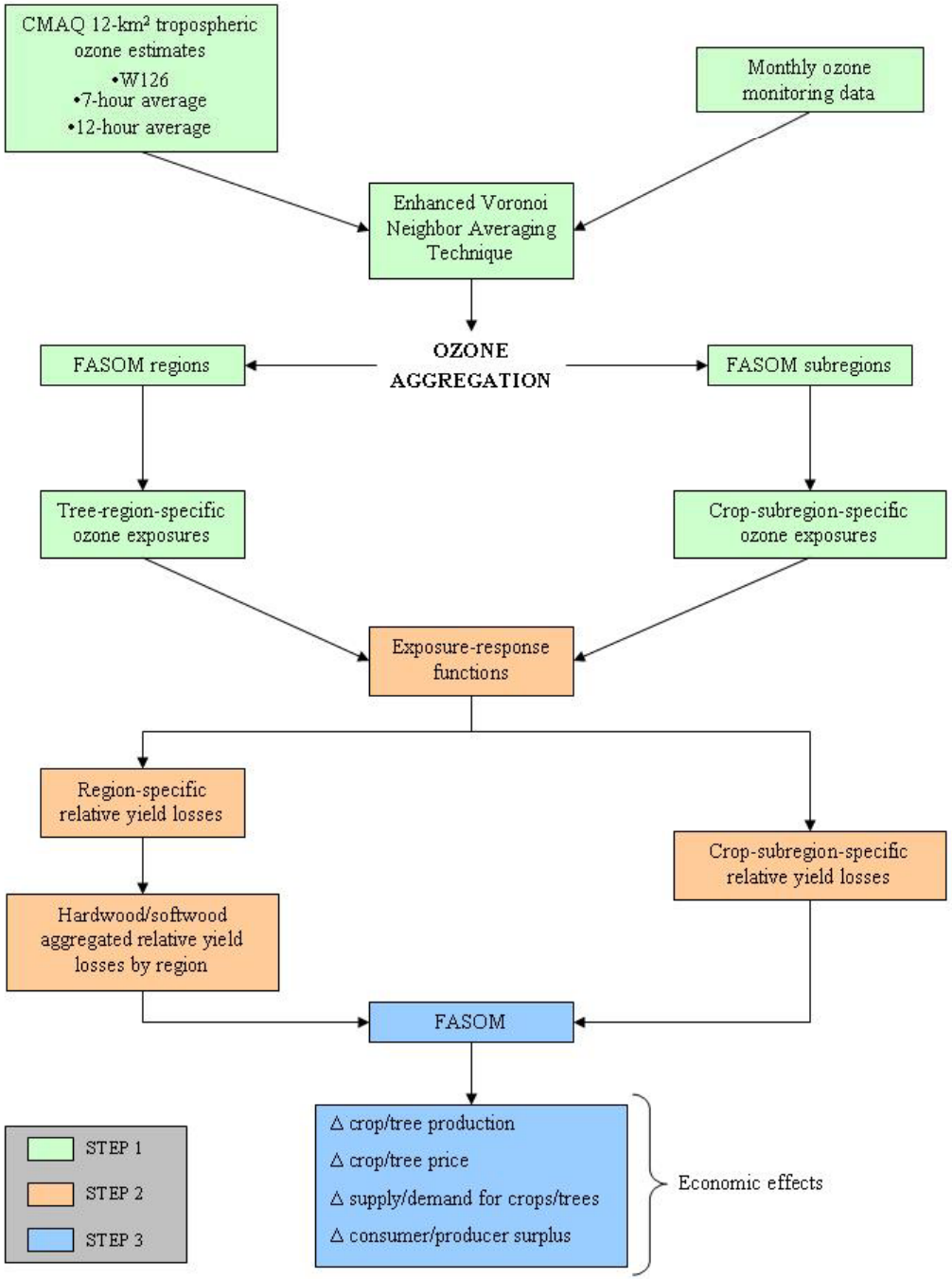
*Sources: 1.) U.S. Forest Service; 2.) N.Y. Dept. of Environmental Conservation; 3.) Environmental Protection Agency; 4.) Environmental Systems Research Institute, Inc.

Adirondack Timber Study: Results Summary

- Ecological endpoint benefit reported is change in percent base saturation by forest type.
- Dose-response functions for Adirondack tree species do not exist to relate changes in percent base saturation levels to tree growth effects.
- Paper birch, eastern hemlock, and sugar maple/beech/birch forest types are predicted to experience the greatest increases in percent base saturation.
- Increases in base saturation in sugar maple/beech/birch forests are likely to have the greatest economic implications given the dominance of this forest type in the Park and the high value of sugar maple.

FOREST TYPE	AREA-WEIGHTED DIFFERENCE IN PERCENT BASE SATURATION			
	2000	2010	2020	2050
Sugar Maple/Beech/Yellow Birch	0.023%	0.414%	0.820%	1.899%
Eastern Hemlock	0.028%	0.413%	0.827%	1.908%
Paper Birch	0.018%	0.457%	0.891%	2.069%

Agricultural and Forest Productivity Benefits

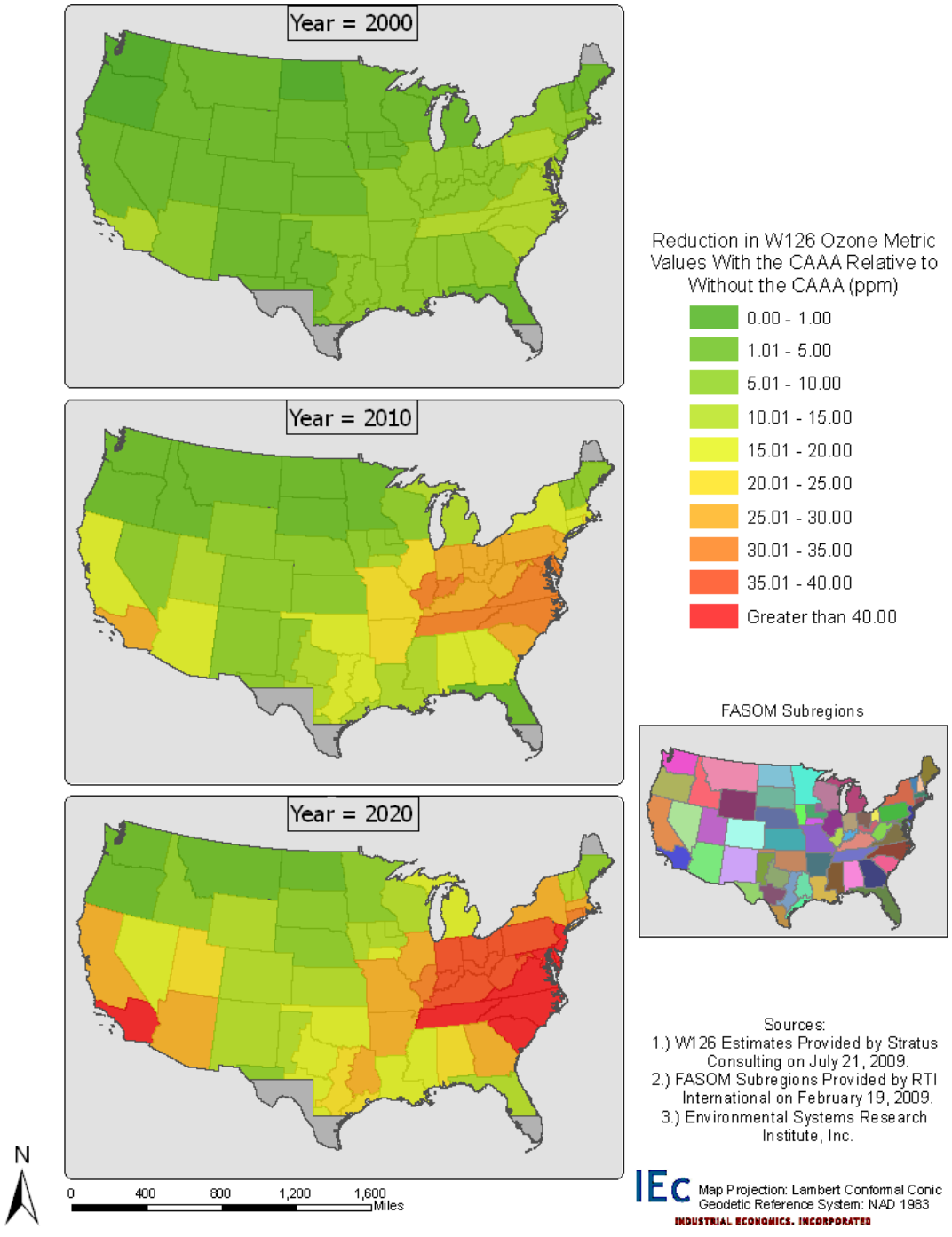


STEP 1: Estimate tropospheric ozone concentrations between 2000 and 2020 across the conterminous U.S. under the baseline and counterfactual scenarios.

STEP 2: Employ crop- and tree-specific exposure response functions to estimate relative yield losses due to increased ozone concentrations under the counterfactual scenario.

STEP 3: Employ the FASOM model to estimate welfare effects (i.e., changes in both producer and consumer surplus) of increased yield in agricultural and commercial timber production (forthcoming).

Reductions in Ozone Concentration With the CAAA by FASOM Subregion (May – September)



- The W126 ozone metric is a weighted sum of all tropospheric ozone concentration values observed hourly between 8 am and 8 pm.
- Virginia, North Carolina, South Carolina, Tennessee, and southern California exhibit the greatest differences in ozone concentration between the baseline and counterfactual scenarios.
- Secondarily, Pennsylvania, West Virginia, Kentucky, Indiana, Illinois, and Ohio exhibit large differences in ozone concentration between the two scenarios.
- Relative yield losses in crops and trees are expected to be greatest in the geographic areas where the differences in ozone concentration between the two scenarios are largest.

Agricultural and Forest Productivity Benefits: Relative Yield Losses

CROP/FOREST TYPE	2000			2010			2020		
	MINIMUM	MAXIMUM	AVERAGE	MINIMUM	MAXIMUM	AVERAGE	MINIMUM	MAXIMUM	AVERAGE
Barley	0.00%	0.02%	0.01%	0.00%	0.06%	0.02%	0.00%	0.07%	0.02%
Corn	0.00%	1.12%	0.18%	0.00%	3.07%	0.44%	0.00%	3.45%	0.56%
Cotton	0.00%	6.60%	1.15%	0.00%	16.67%	3.00%	0.00%	20.31%	3.81%
Oranges	0.00%	1.95%	0.09%	0.00%	4.68%	0.25%	0.00%	7.87%	0.43%
Potato	0.00%	6.17%	1.76%	0.00%	17.54%	**4.99%**	0.00%	**20.80%**	**6.50%**
Rice	-0.08%	0.14%	0.00%	0.00%	1.03%	0.11%	0.00%	1.66%	0.18%
Sorghum	0.00%	0.87%	0.14%	0.00%	2.17%	0.35%	0.00%	2.65%	0.47%
Soybean	0.00%	3.60%	1.24%	-0.55%	11.73%	3.07%	0.00%	12.74%	4.26%
Processing Tomatoes	0.00%	1.82%	0.31%	0.00%	5.54%	0.96%	0.00%	8.21%	1.47%
Spring Wheat	0.00%	1.50%	0.06%	0.00%	3.67%	0.15%	0.00%	6.98%	0.28%
Winter Wheat	0.00%	6.53%	1.00%	0.00%	18.23%	2.49%	0.00%	19.23%	3.29%
Hardwood Forests	1.60%	7.16%	5.06%	4.20%	19.12%	**13.86%**	6.61%	**23.04%**	**16.68%**
Softwood Forests	0.06%	3.85%	1.77%	0.25%	10.49%	4.88%	0.42%	12.27%	6.11%

- RYLs increase over time.
- Cotton, potatoes, soybeans, and winter wheat, as well as both hardwood and softwood forest types exhibit the greatest RYLs in all years.
- The greatest RYLs for both crops and trees occur in the Southeast, most frequently in Virginia, North Carolina, South Carolina, and Tennessee.

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