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Second Prospective Benefits Analysis: Briefing on Visibility, Ecological, and Materials Damage Benefits from April 2010 Report

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- Robert Beach, RTI (FASOM model)

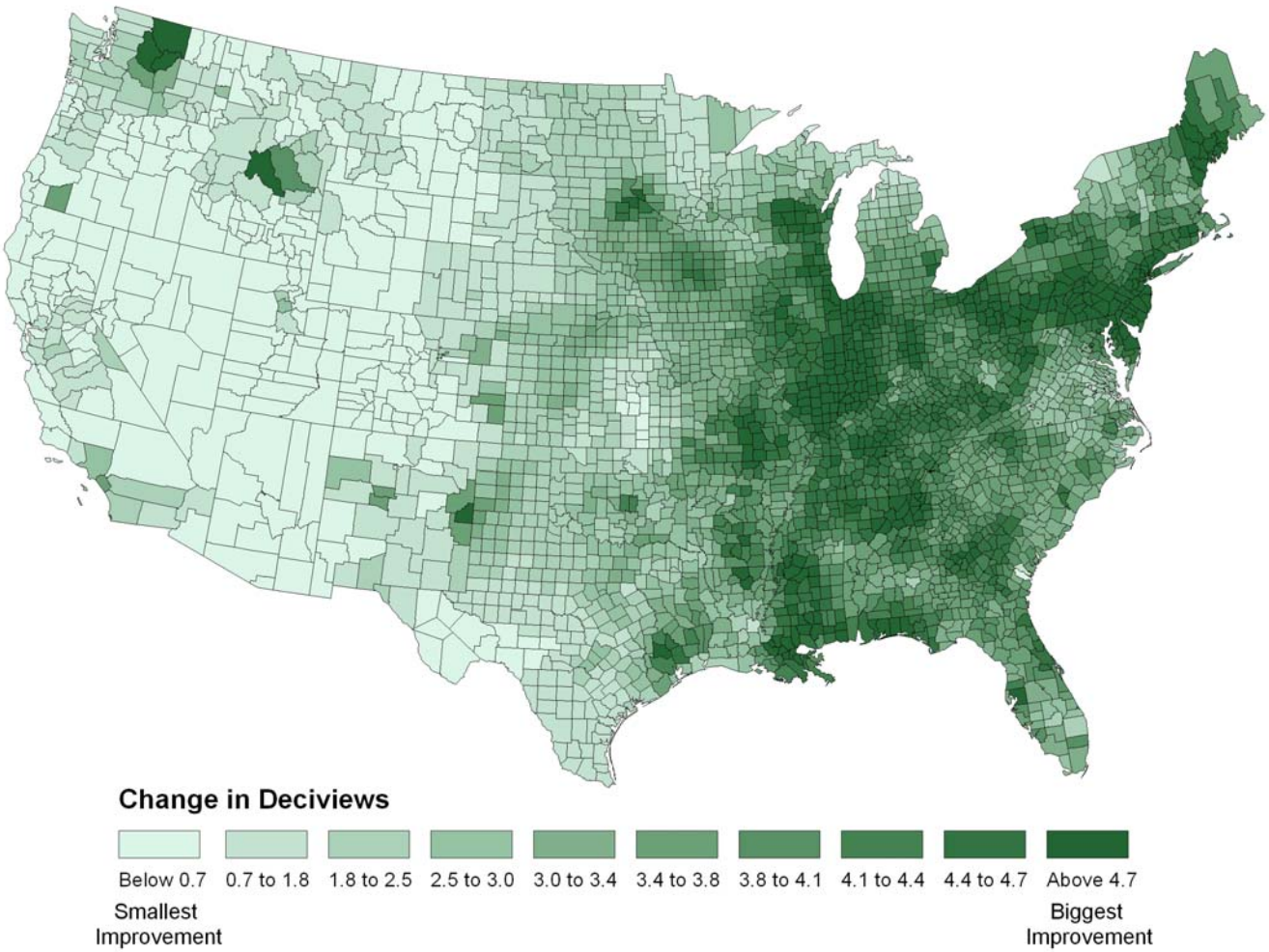
Briefing Outline

- Some Challenges in Welfare Effects Analysis
- Summary of Visibility Analysis (Chapter 3 in Benefits Report)
- Summary of Ozone Effects Analysis on Timber and Agricultural Production (Chapter 4 in Benefits Report)
- Summary of Materials Damage Analysis (Chapter 5 in Benefits Report)
- Lake Acidification Benefits Analysis (Chapter 4 in Ecological Report)

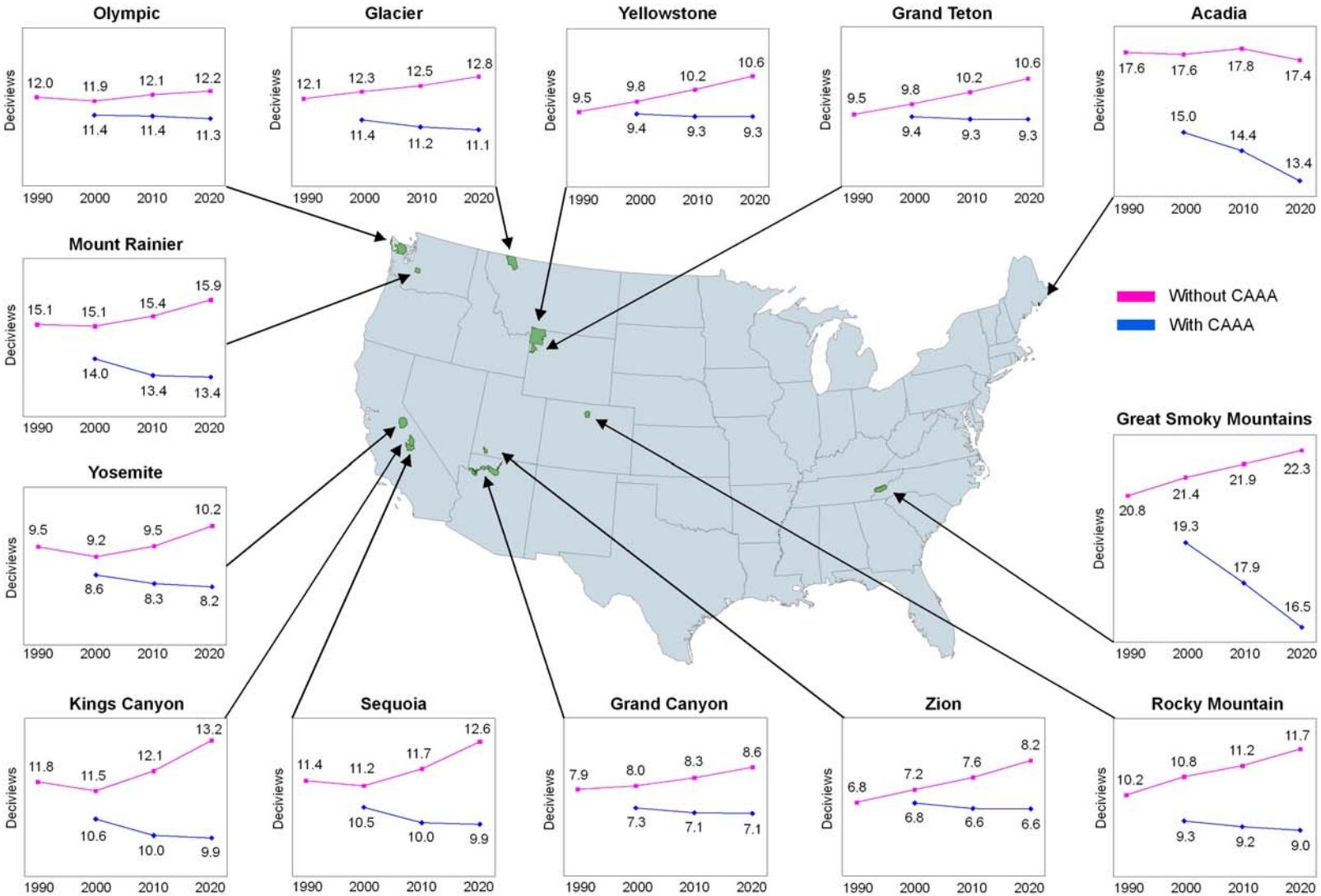
Key Challenges in Welfare Effects Analysis

- Developing appropriate air quality inputs:
  - Visibility from CMAQ, adjusted for PM emissions correction
  - Ozone measures linked to plant productivity
  - Measures of materials exposure to acids
  - Measures of lake acidification
- Physical effects estimates:
  - C/R functions for plant productivity and materials damage
  - Measures of fish habitat quality in lakes
- Identifying and implementing valuation strategies:
  - Welfare models for ag/forests, lake acidification
  - Benefits transfer for visibility
  - Expenditure changes for materials damage

Visibility Measures – with-CAAA Trajectory



Visibility Measures – Improvements at Nat'l Parks



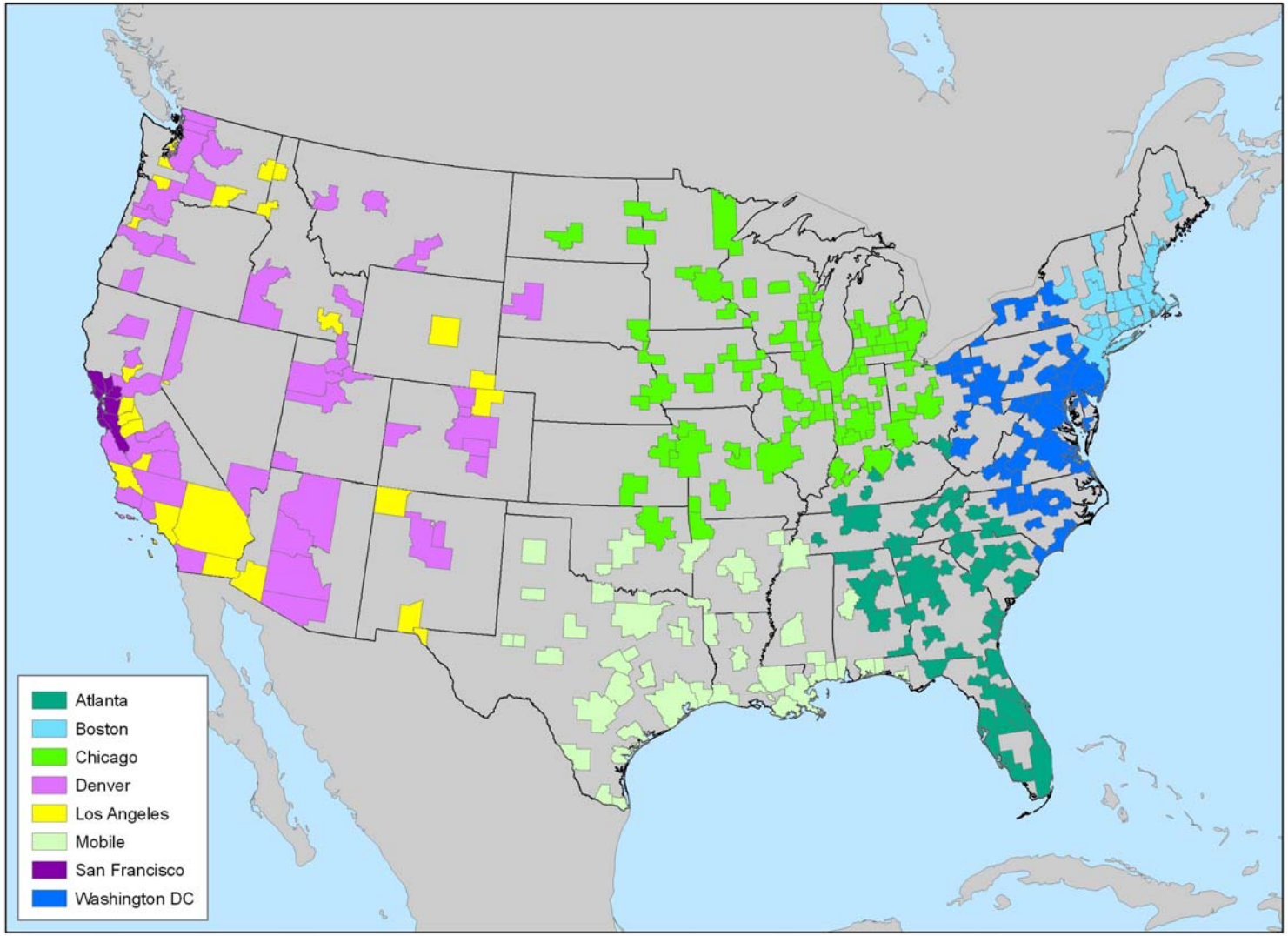
Summary of Visibility Methods: Recreational

- Use methodology from Particulate Matter NAAQS RIA.
- Applies WTP estimates from Chestnut and Rowe (1990)
- Benefits transfer is application of the Constant Elasticity of Substitution (CES) utility function approach, preference calibration method developed by Smith, Van Houtven, and Pattanayak (1999).
- Central estimate applies method to national parks and wilderness areas in California, the Southwest, and the Southeast. These regions cover 86 of the 156 Class I areas in the United States.

Summary of Visibility Methods: Residential

- Newly developed methodology for this analysis.
- Applies WTP estimates from three CV studies: Brookshire (1979), Loehman (1984) and Tolley (1986), covering a total of eight cities.
- Benefits transfer is based on “matching” MSAs with study cities, and direct application of WTP values per deciview change.
- Central estimate applies method to all US MSAs, but excludes benefits outside MSAs.

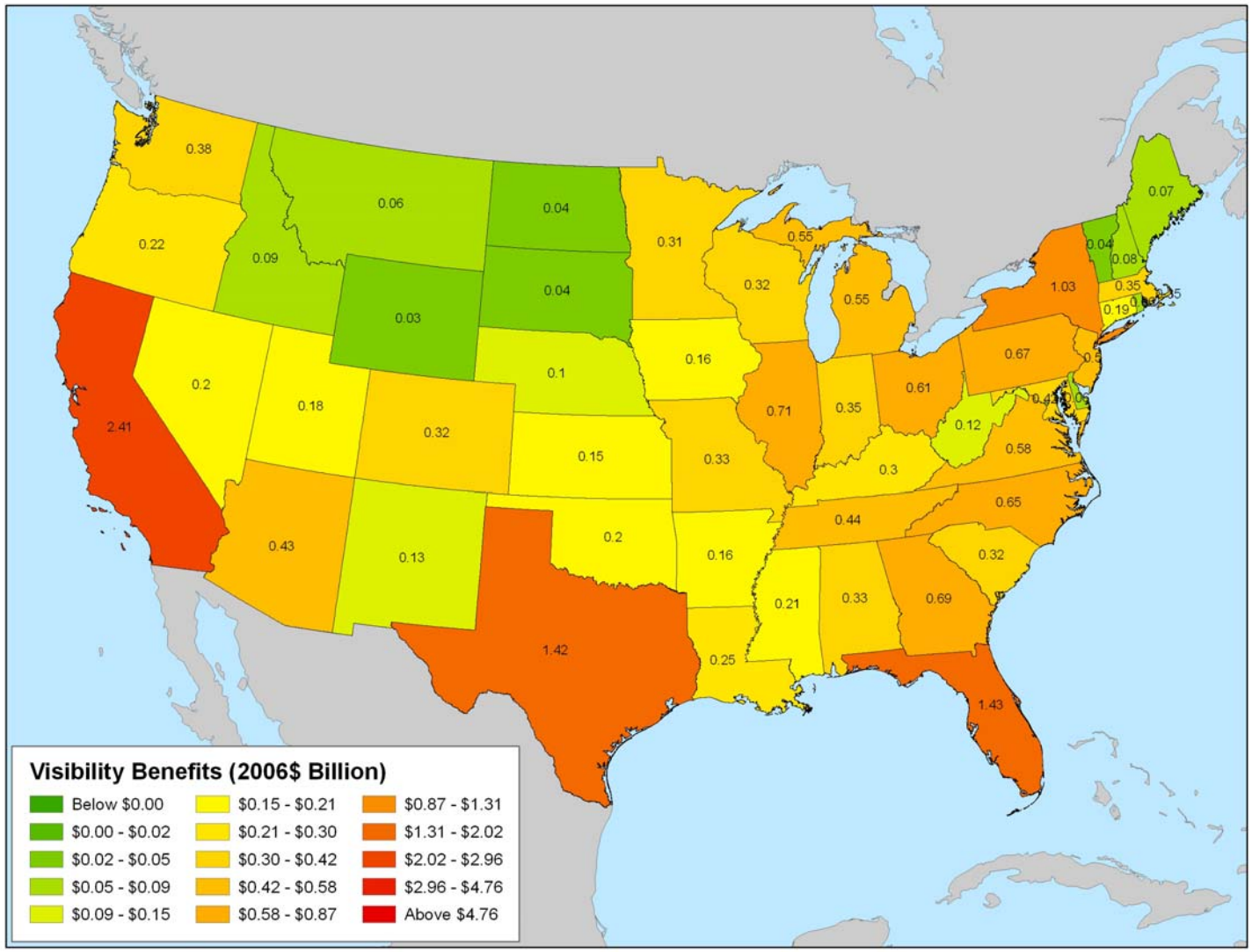
Residential Visibility Methods: Study City Assignment



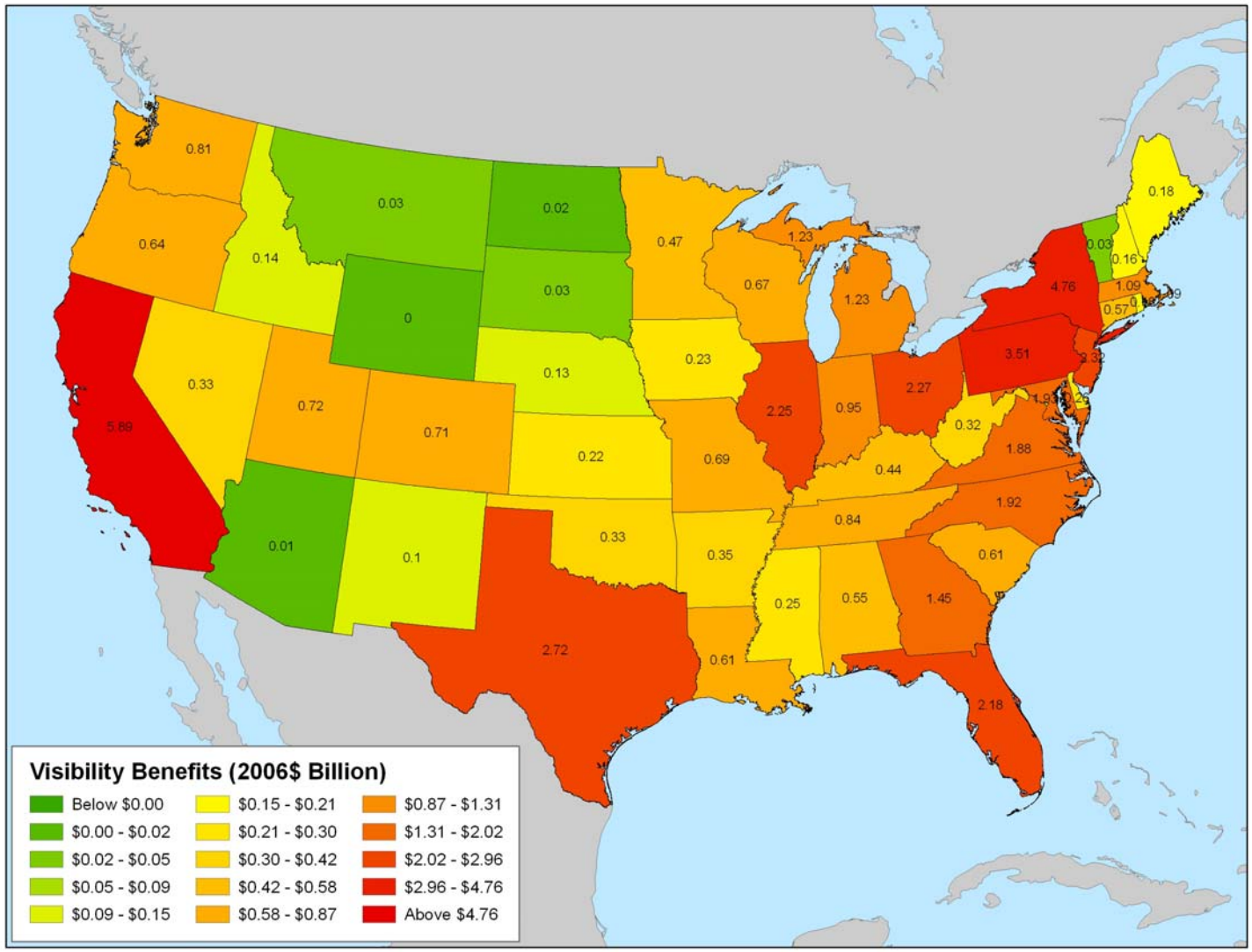
Visibility Results: Total (billion 2006$)

	2000 BENEFITS	2010 BENEFITS	2020 BENEFITS
Recreational Benefits	$3.3	$8.6	$19
Residential Benefits	$11	$25	$48
Total Benefits	$14	$34	$67

Visibility Results - Recreational



Visibility Results - Residential



Visibility – Comparison to First Prospective Results

- 1st Prospective only considered benefits to recreational visibility due to concerns about the methods used in the residential visibility study by McClelland et al. (1991).

- 1st Prospective estimates recreational visibility benefits of $3.1 billion in 2000 and $4.5 billion in 2010 (2006$), much smaller than in 2nd prospective ($3.3 billion in 2000 and $8.6 billion in 2010).

- Difference largely due to differences in the air quality estimates, and larger estimated emission reductions in 2nd Prospective Analyses.

Uncertainty in Visibility Methods

DATA SOURCE	ASSUMPTION	EFFECT
Recreational Visibility		
Chestnut and Rowe, 1990a Chestnut and Rowe, 1990b Chestnut, 1997	Chestnut and Rowe study covers parks in three regions: California, Southwest, and Southeast.	Unclear
	Chestnut and Rowe study conducted on populations in five states. These results are applied to the entire U.S. population.	Unclear
	Only includes benefits to National Parks and Wilderness Areas, other recreational settings are not included in this analysis.	Potential Underestimate
	Individuals have a greater WTP for visibility changes in parks within their region.	Unclear
	WTP values reflect only visibility improvements and not overall air quality improvements.	Potential Overestimate
Residential Visibility		
Tolley et al., 1986 Brookshire et al., 1979 Loehman et al., 1984	Residential and recreational visibility benefits are distinct and separable.	Potential Overestimate
	Estimates residential visibility benefits within the boundaries of MSAs. Areas outside of an MSA are not included in this analysis.	Potential Underestimate
	WTP values reflect only visibility improvements and not overall air quality improvements.	Potential Overestimate
	WTP values from study cities can be accurately transferred to MSAs across the U.S.	Unclear

Screenshot of Visibility Tool

Year of Analysis

2020

The selected year determines the income, population, park visitation, and visibility levels used in the analysis.

Dollar-Year for Displaying Results

2006

The selected year determines the dollar-year in which values are displayed in the table below.

Basis for Determining Residential Visibility Values

Elevation

The option selected determines how residential visibility values are assigned to areas outside of the original study locations.

Elevation -- MSAs with elevation ranges exceeding the cutoff value entered below are assigned the value produced by the Denver study, while all others are assigned based on proximity alone (excluding Denver).

Proximity to Study City -- MSAs are assigned the value of the nearest study city (including Denver), with an exception for values produced by the San Francisco study, which are assigned to other MSAs on a very limited basis.

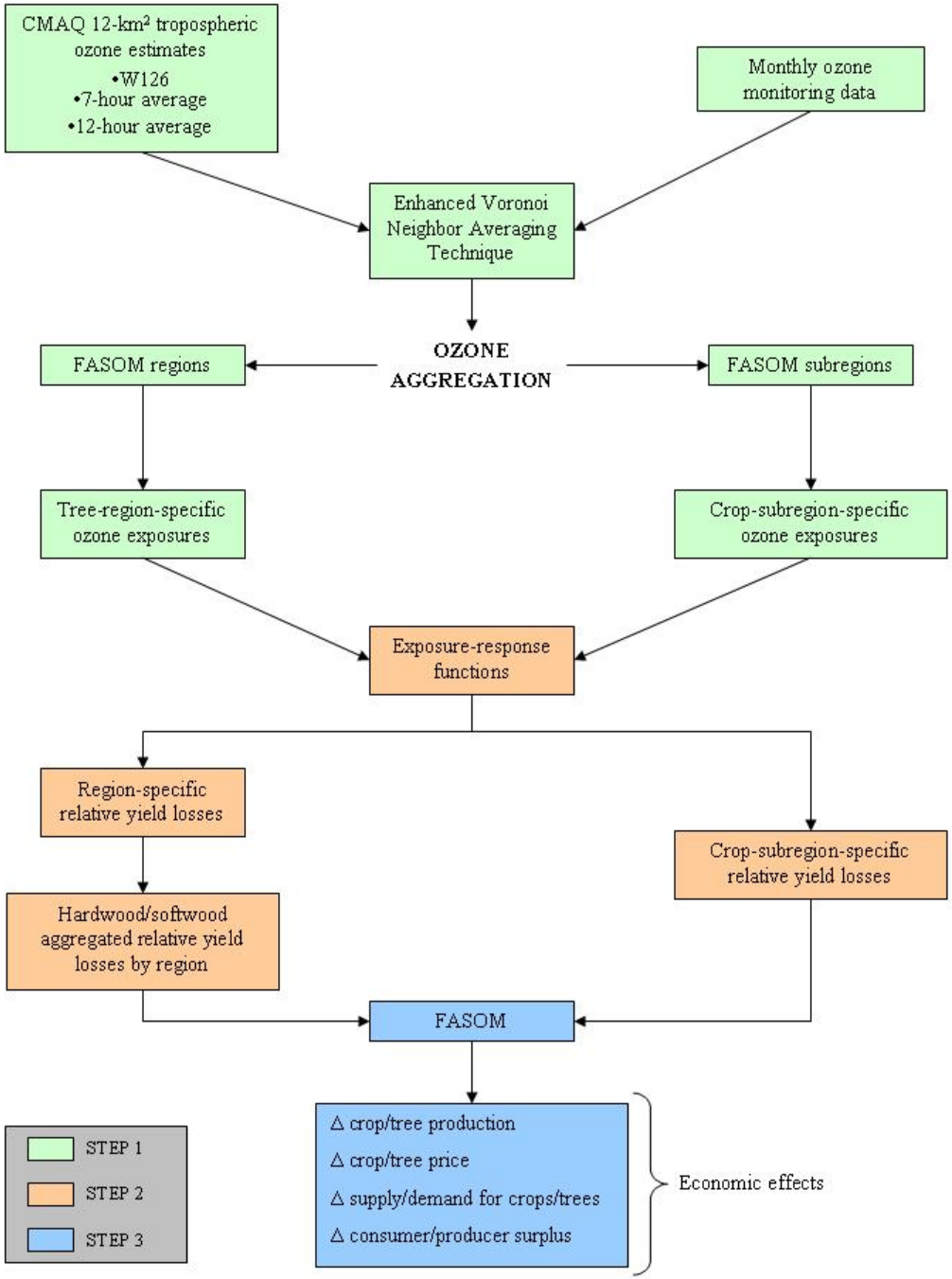
Elevation Range Cutoff

1500 Meters

The selected value determines the cutoff at which MSAs are considered to have potential for above-average vistas and are therefore thought to be most comparable to Denver rather than the closest MSA.

		Recreational Visibility			
		Option A Total benefits; original study regions only		**Option B** Total benefits; all regions	
Residential Visibility	**Option A** Only MSAs outside original study regions (benefits not additive)	Recreational Benefits	$18,721,561,027	Recreational Benefits	$25,512,008,243
		Residential Benefits	$27,581,164,561	Residential Benefits	$27,581,164,561
		Total Benefits	**$46,302,725,588**	**Total Benefits**	**$53,093,172,804**
	Option B All MSAs (benefits additive)	Recreational Benefits	$18,721,561,027	Recreational Benefits	$25,512,008,243
		Residential Benefits	$48,187,592,556	Residential Benefits	$48,187,592,556
		Total Benefits	**$66,909,153,583**	**Total Benefits**	**$73,699,600,800**

Agricultural and Forest Productivity Benefits

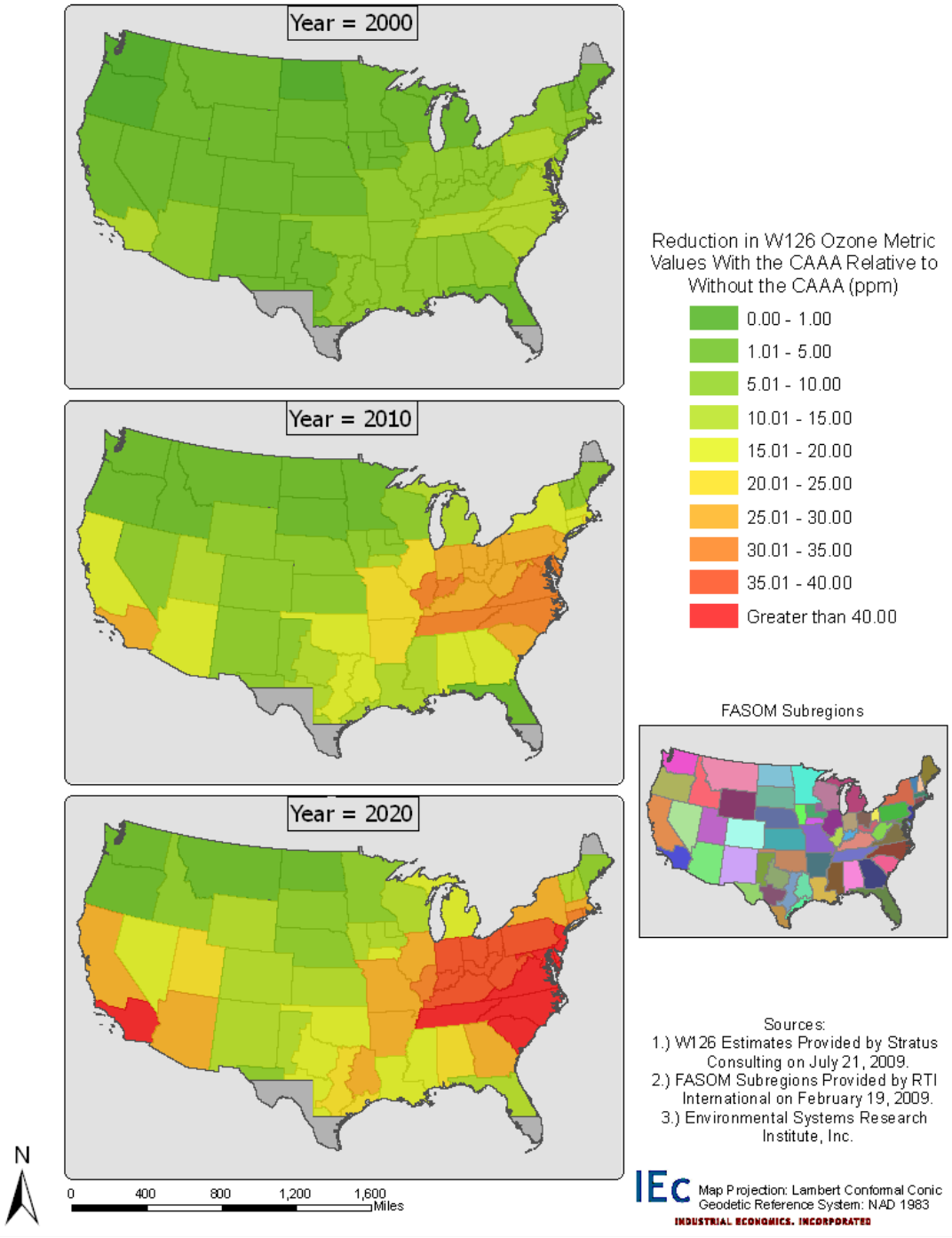


STEP 1: Estimate tropospheric ozone concentrations between 2000 and 2020 across the conterminous U.S. under the baseline and counterfactual scenarios.

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.

Agricultural and Forest Productivity Benefits: Economic Welfare Results

- In process of applying the Forest and Agricultural Sector Optimization Model (FASOM)
- Results not yet available

Materials Damage Methods

- Adopt approach from Air Pollution Emissions Evaluation for Policy (APEEP) model (Muller and Mendelsohn 2007, 2009)
- Acid exposure estimates from APEEP module, calibrated to CMAQ
- Inventory of susceptible materials had been key missing link
- C/R functions from NAPAP (mid-1980s) and International Cooperative Programme on Effects on Materials (1998).
- Expenditure-based valuation based on cost of shortened maintenance cycle

Materials Damage Results

EPA REGION	VALUATION (THOUSAND 2006$)		
	2000	2010	2020
1: CT, ME, MA, NH, RI, VT	$720	$2,100	$2,100
2: NY, NY	$9,000	$10,000	$12,000
3: DE, DC, MD, PA, VA, WV	$9,400	$19,000	$23,000
4: AL, FL, GA, KY, MS, NC, SC, TN	$8,400	$16,000	$21,000
5: IL, IN, MI, MN, OH, WI	$26,000	$38,000	$38,000
6: AR, LA, NM, OK, TX	$2,200	$4,000	$7,300
7: IA, KS, MO, NE	$2,000	$1,600	$1,600
8: CO, MT, ND, SD, UT, WY	$400	$570	$730
9: AZ, CA, NV	-$100	$490	$640
10: ID, OR, WA	$340	$510	$560
Total	**$58,000**	**$93,000**	**$110,000**

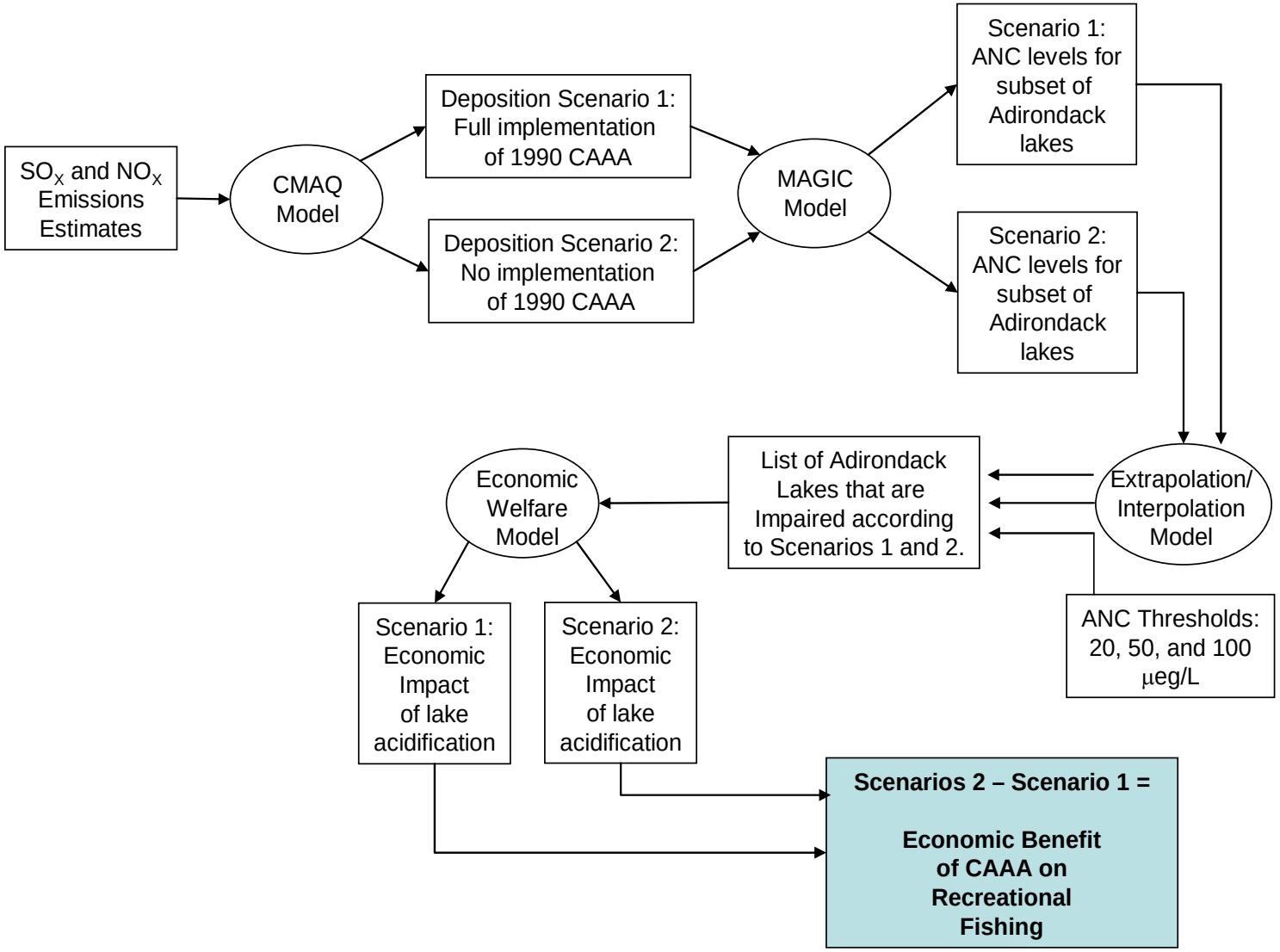
Notes: Results are rounded to two significant figures. Totals may not sum due to rounding.

Adirondack Recreational Fishing Case Study: Overview

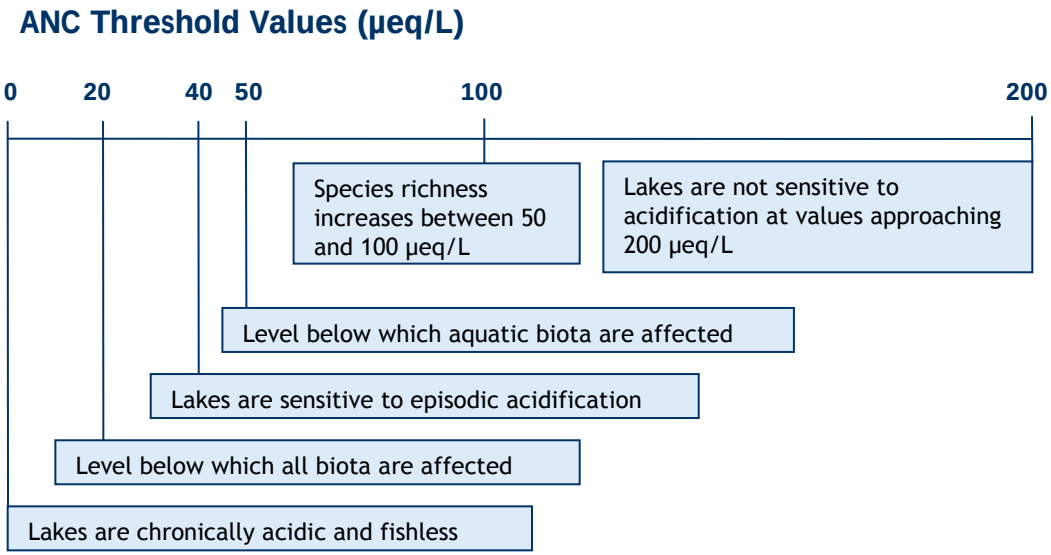
- Case study considers the economic benefit of reduced acidic deposition on the value of recreational fishing (i.e., willingness to pay) for lakes within the Adirondacks and anglers in New York State.

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

Recreational Fishing Study: Conceptual Framework



Recreational Fishing Case Study: Lake Impairment



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: 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: Comparison to 1st Prosp.

- Annual and cumulative estimates in the first prospective analysis were much larger than those presented here.
  - 1st Prospective: primary central benefits in 2010 = $50 million (1990$)
  - 2nd Prospective: primary central benefits in 2020 = $8.6 million (2006$)
- Might have expected estimates to be larger in 2nd Prospective, because of much larger reductions in sulfur and nitrogen emission reductions attributable to CAAA.
- However, methods and data have changed in many ways, as a result estimates are probably no longer comparable:
  - Use of ANC levels in 2nd Prospective instead of pH as the measure of lake acidification in MAGIC model
  - Use of ANC threshold versus pH-based threshold to define if lake was fishable.
  - Use of CMAQ to model deposition, rather than Regional Acid Deposition Model (RADM).

Recreational Fishing Study: Key Uncertainties

- 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.

Net Effect: We probably underestimate the full value of this benefit.

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