

# *Impacts of Ozone Pollution and Reductions for Low-Income Households*

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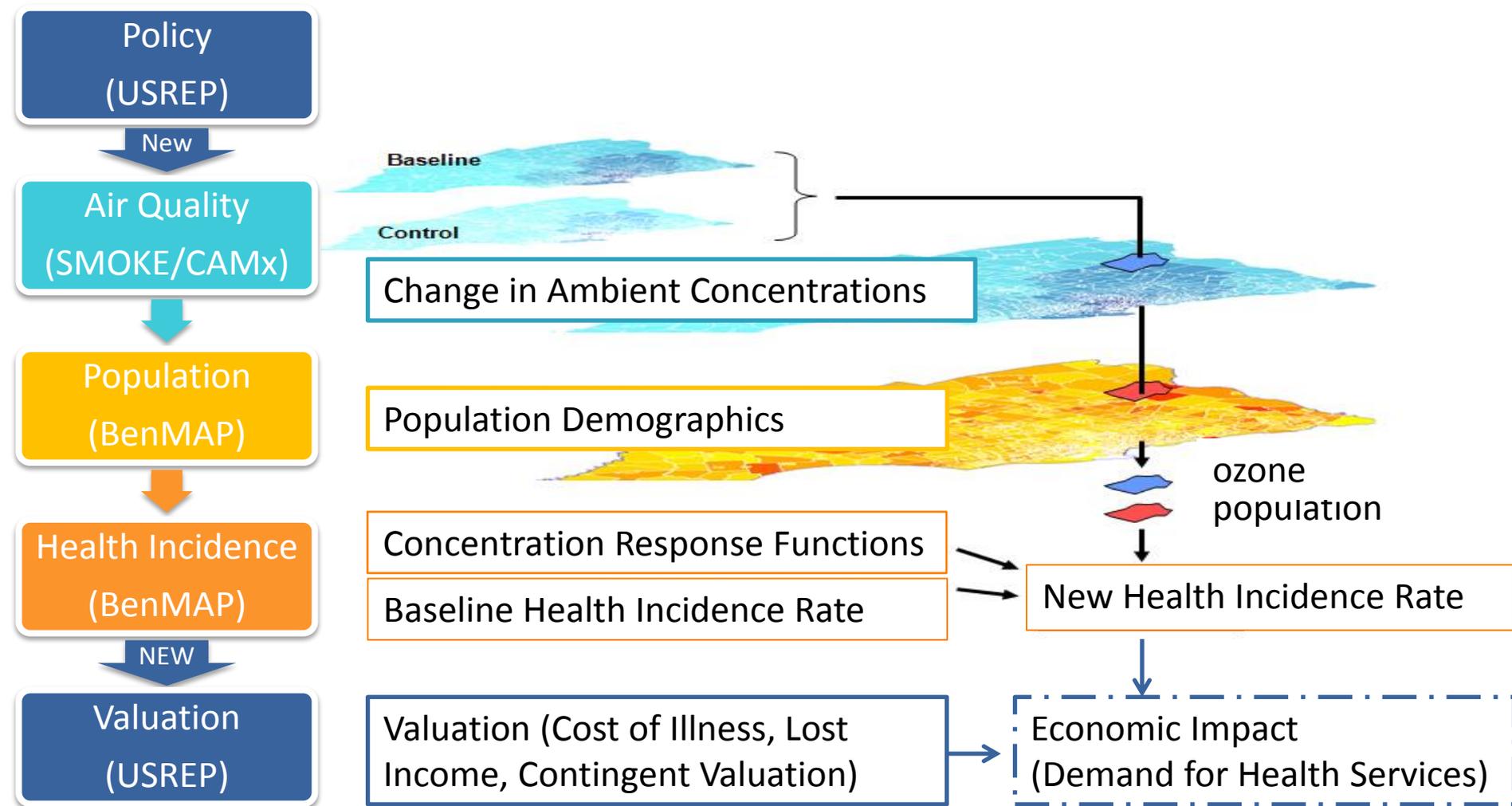
Tammy M. Thompson<sup>2</sup>, Noelle E. Selin<sup>1</sup>

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1 MIT 2 CSU

# Integrated Modeling of Air Quality Co-Benefits



Thompson, T.M., S. Rausch, R.K. Saari, N.E. Selin (2014), *Nature Climate Change*  
 Saari, R.K., N.E. Selin, S. Rausch, T.M. Thompson (2014), *J. Air Waste Manage. Assoc.*

# U.S. studies say ozone exposure can decrease with income

Study	Population	Does ozone decrease with income?
Miranda et al., 2011	<10% of population (near monitors)	<b>NO</b> (smaller % living in poverty exposed)
Grineski et al., 2007	Phoenix	<b>YES</b>
Marshall, 2008	South California	<b>NO</b> (lower exposure for households < \$50K)
Liu, 1998	<10% of population (near monitors)	<b>NO</b> overall <b>YES</b> for urban areas <b>NO</b> for rural areas
Liu, 1996 Liu, 1996	NY, PA, Houston, LA	<b>NO</b> (rich downwind suburbs)
<b>Saari et al., 2014 (This Work)</b>	<b>Continental U.S. (Modeling experiment)</b>	<b>YES</b> <b>Pattern varies by region</b>

# Research Questions

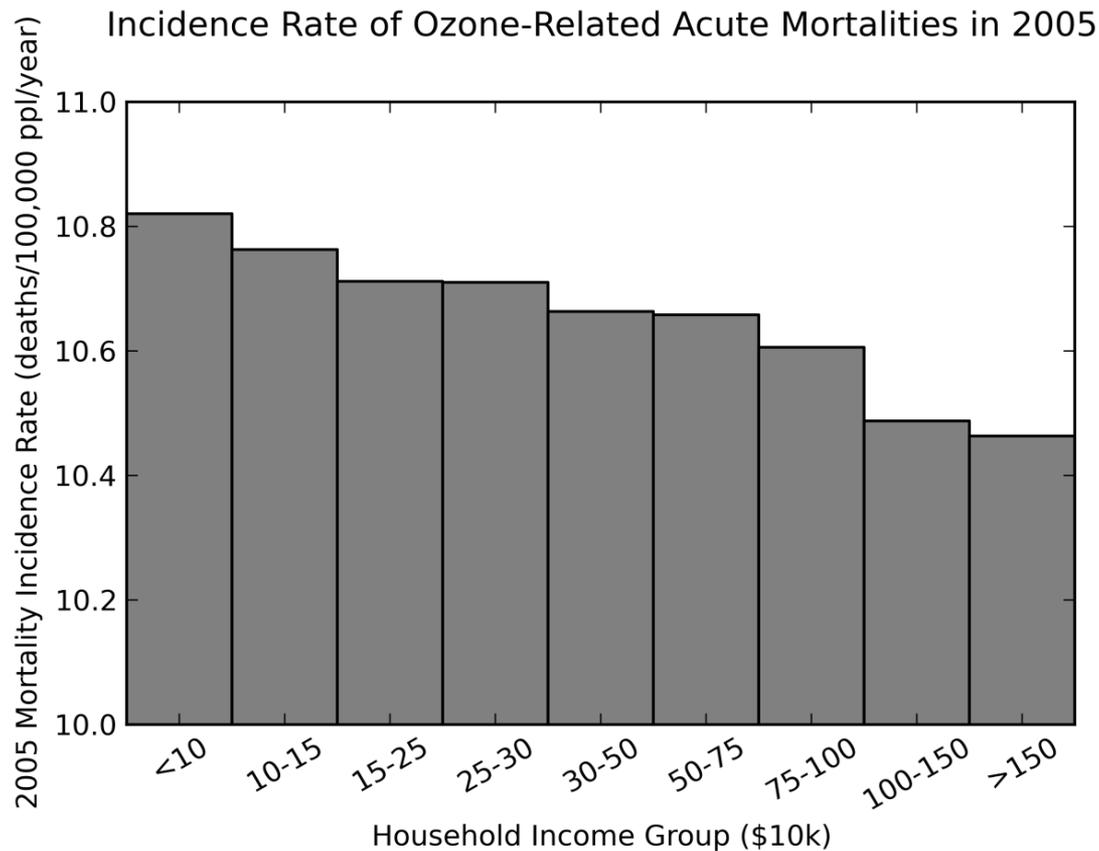
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## How does modeled inequality in ozone exposure affect the relative economic value of reducing ozone (with EPA policies) for low-income households?

- What do *modeled* U.S. ozone levels in 2005 imply for health outcomes by income group?
- What is the economic benefit of *planned* ozone reductions for 2014, over time (up to 2100), and by income group? What is the relative economic effect of delaying reductions on low-income households?

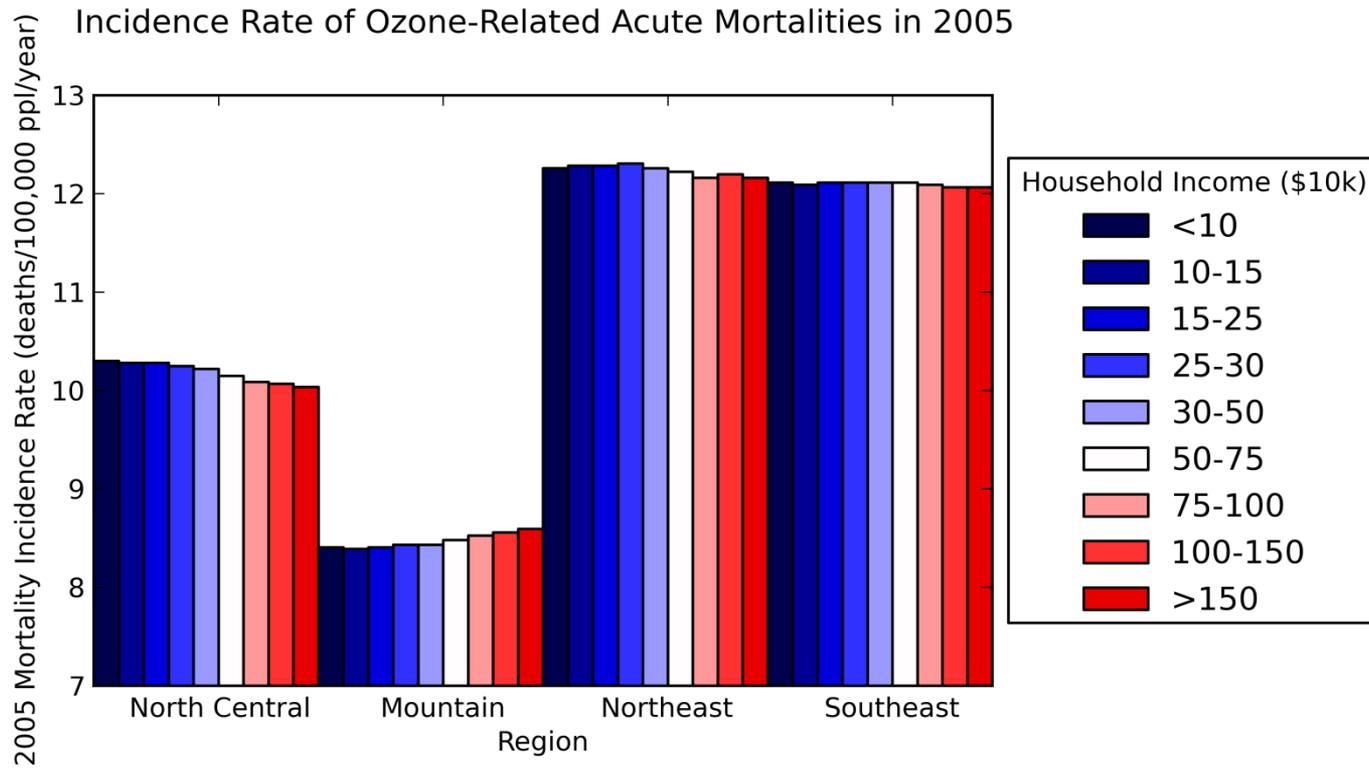
# Mortality Incidence by Income Group

- What do MODELED differences in 2005 ozone levels imply for mortality rates? Only difference between income groups is modeled level of ozone.
- Ozone levels in 2005 imply incidence rate of 11 deaths/100,000 people
- Incidence rate is 3% higher for lowest income than highest income



# Mortality Incidence by Income & Region

Specific regions will have decreasing, increasing, flat incidence rates



# Research Questions

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- What do modeled U.S. ozone levels in 2005 imply for health outcomes by income group?
  - **Decreasing with income due to difference in exposure, nationally, incidence rate estimated is 3% higher among low income households**
  - **Pattern of incidence with income varies by region**
- What is the economic benefit of planned ozone reductions for 2014, over time, and by income group? What is the relative economic effect of delaying reductions on low-income households?

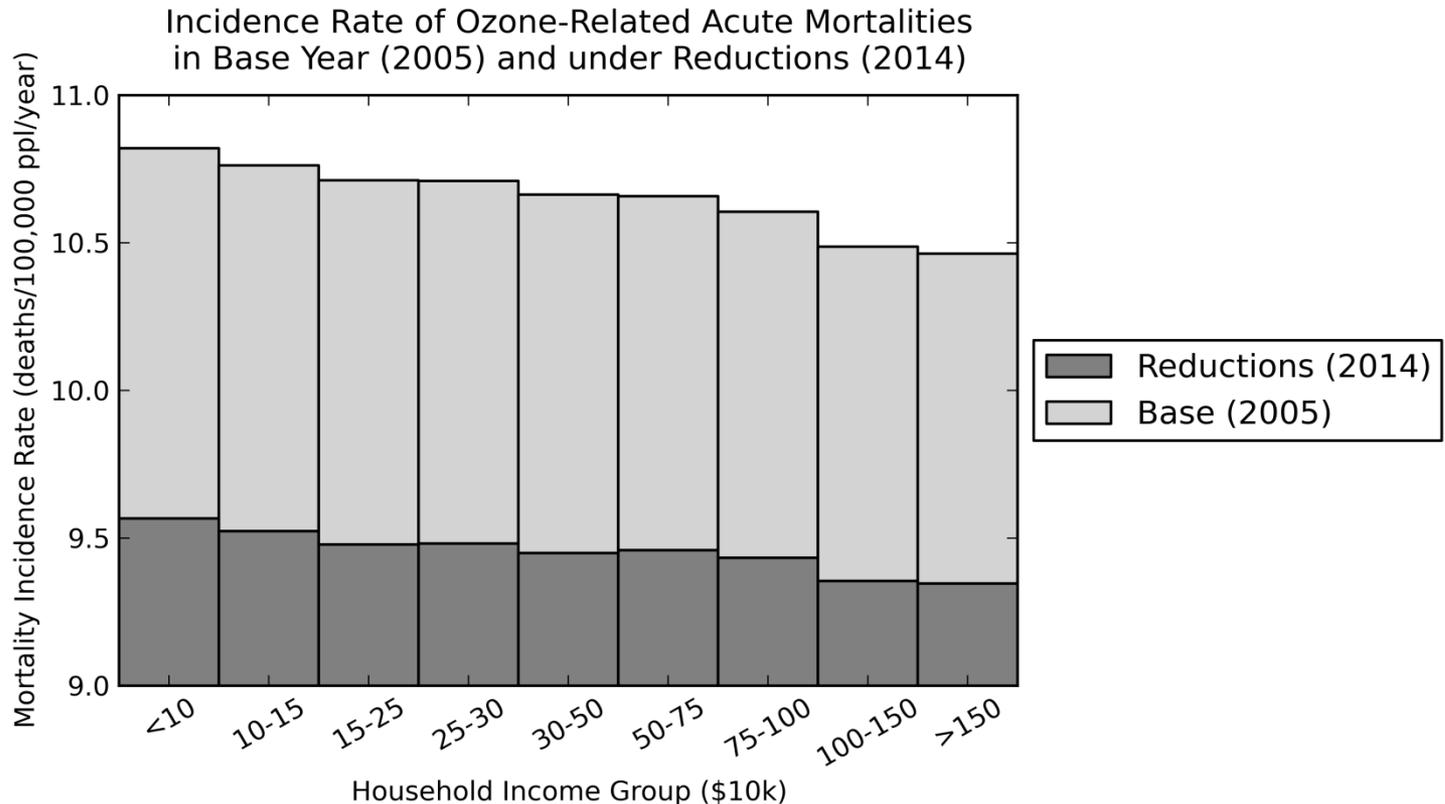
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# Policy-related reductions in mortality rates

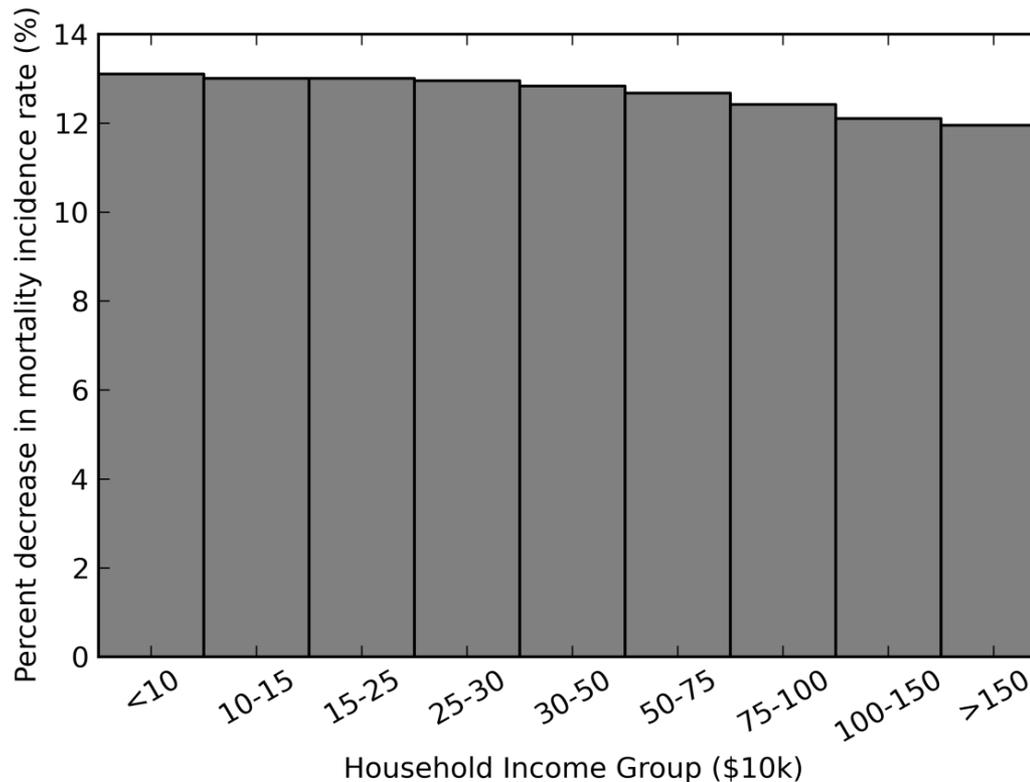
Under the modeled reductions planned for 2014, ozone-related mortality incidence rates decrease by about 1.2 deaths per 100,000 people per year in 2014 (% to follow)



# Percent reductions in mortality rates

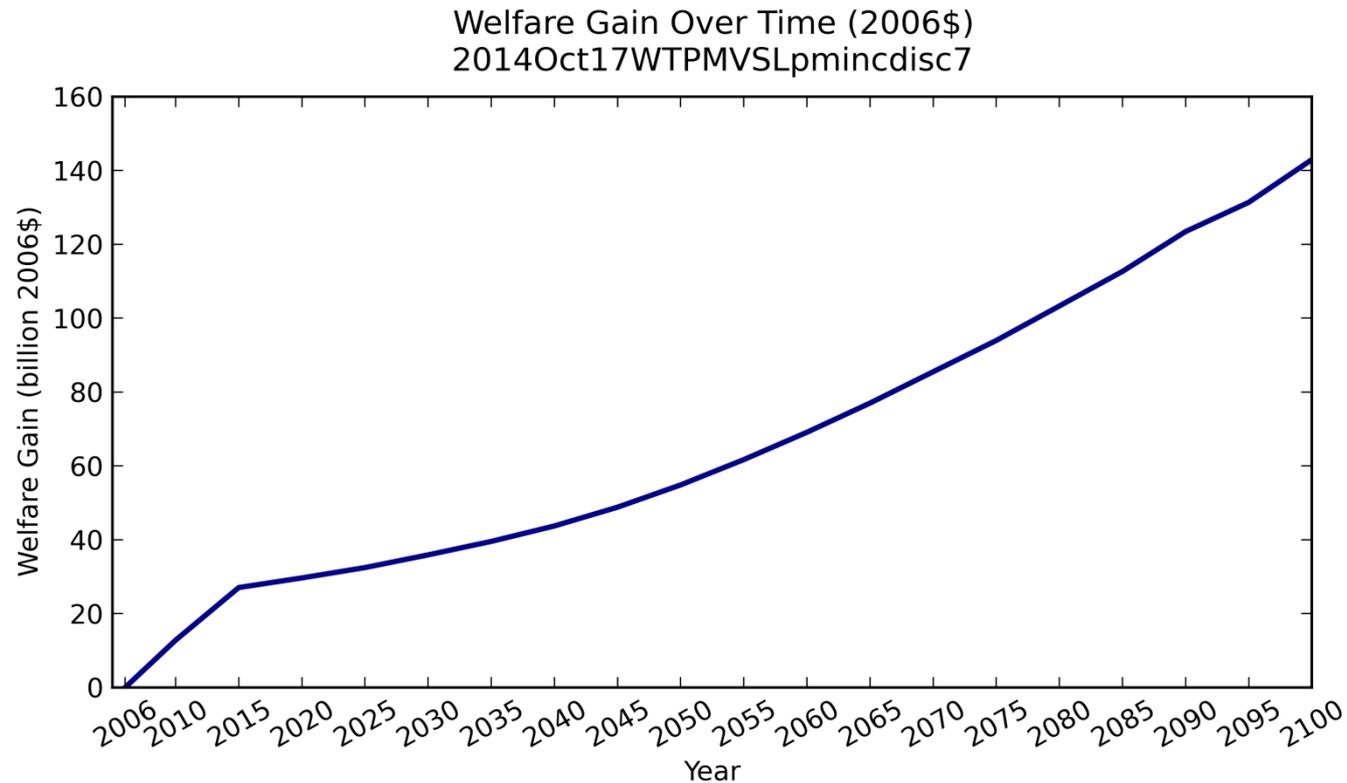
- Ozone reductions are estimated to lower ozone mortality incidence rates by 13%
- This decreases with income monotonically from 13% to 12%

Percent Reduction in Incidence Rate of Ozone-Related Acute Mortalities



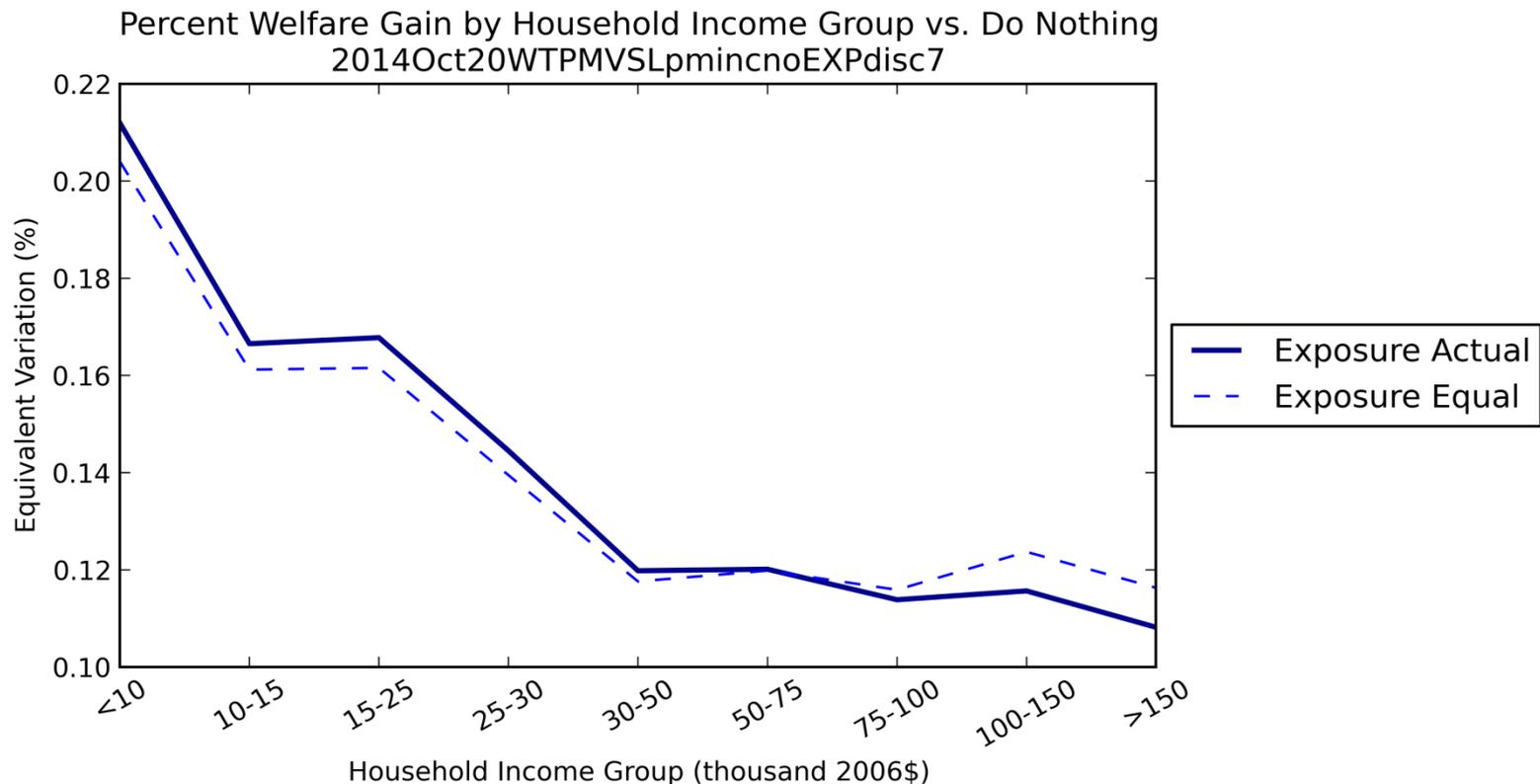
# Annual gains from ozone reductions

- Undiscounted annual welfare gains over time of reductions vs. 2005 ozone levels
- Accounts for change in mortality as well as 4 other endpoints
- Reductions implemented between 2006 and 2014
- Annual gains grow from \$30 billion in 2014 (agrees with BenMAP) to \$150 billion by 2100



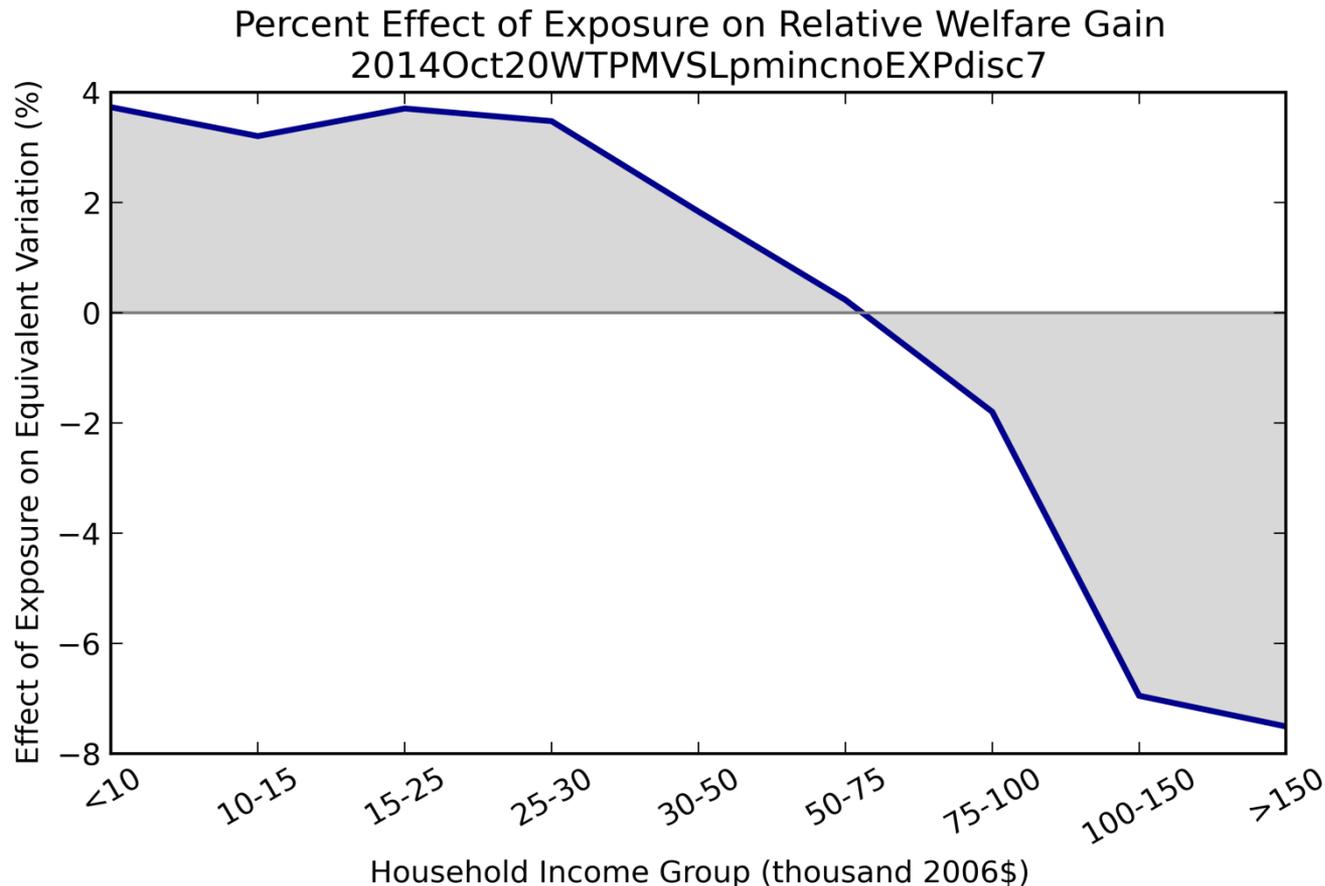
# Exposure and gains by income group

- Per capita welfare gain decreasing with income, up to 0.21% of per capita welfare
- Lowest income households gains twice as much as highest incomes (0.21% vs. 0.11%)
- Slope of relative gain determined more by underlying economics than exposure (difference between solid (exposure weighted) and dashed lines shows effect of exposure)



# Effect of Exposure on Relative Gains

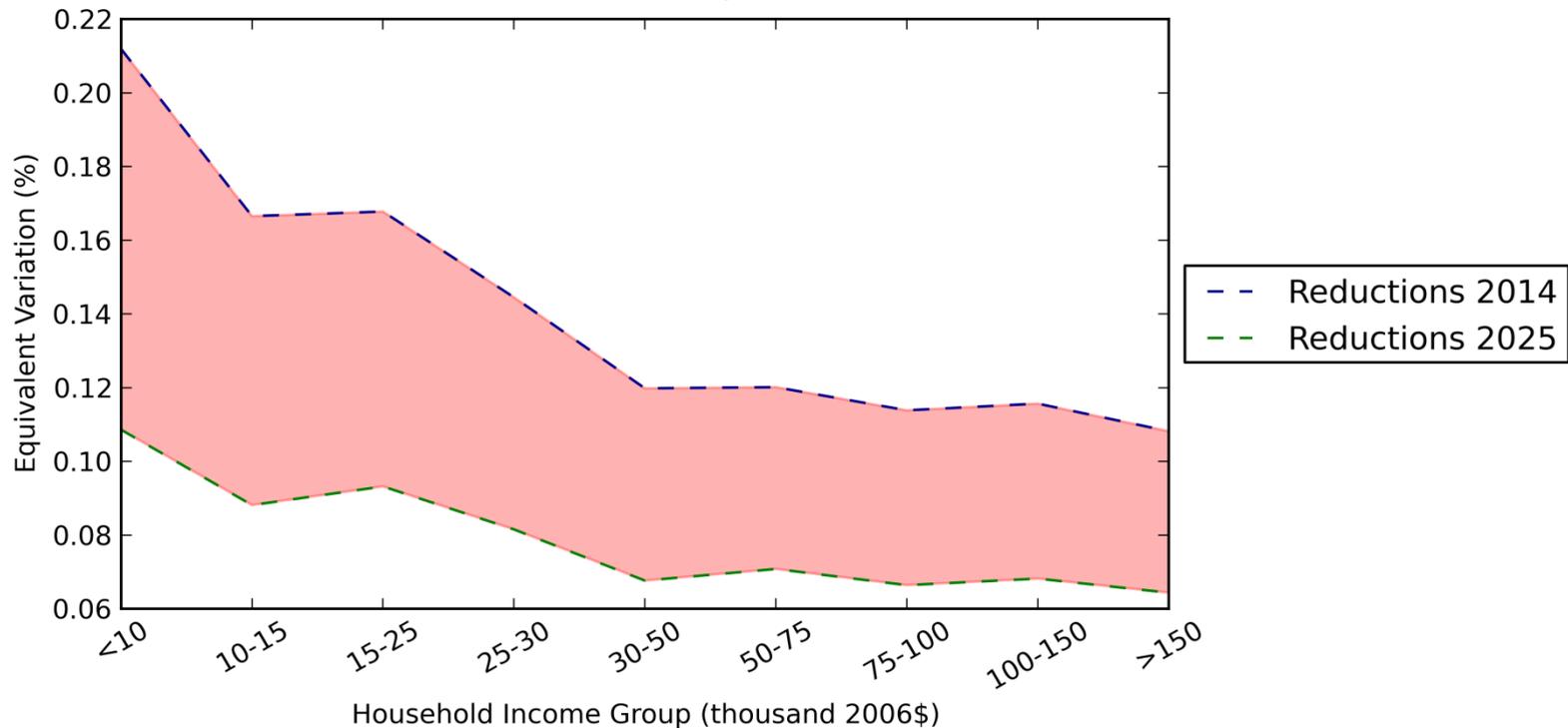
- Treating exposure as equal by income group would understate relative welfare gains for the poor (by about 4%), and overstate them for the rich (by up to 8%)



# Effect of delay on relative gains

- Shaded area shows loss from delaying regulations (7% discount rate)
- Delay foregoes 0.1% of gains for lowest incomes, and 0.05% for highest incomes
- Delay is twice as harmful in a relative sense for lowest vs. highest income households

Effect of Delay on Percent Welfare Gain by Household Income Group vs. Do Nothing  
2014Oct17WTPMVSLpmincdisc7



# Conclusions

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## **What do U.S. ozone levels in 2005 imply for health outcomes by income group?**

- Exposure differences suggest mortality incidence rate is 3% higher in lowest income households than highest income households

## **What is the benefit of planned ozone reductions for 2014? What is the effect of delay?**

- Inequality in exposure makes reductions 4% more valuable, relatively speaking, for low incomes, and up to 8% less valuable for high incomes
- Inequality in income and exposure together means that relative values of reductions are twice as high for the lowest as the highest incomes. Similarly, the loss from delaying regulations is twice as harmful to the lowest incomes

# Limitations and Future Work

## Limitations

- Using modeled ground-level ozone to estimate exposure
- Using concentration-response functions to estimate incidence rates, and these do not account for potential differences in sensitivity or behavior by income group
- Categorizing households by income group (e.g., within-group variability)

## Ongoing Work

- 95% CI to include uncertainty range in impact estimates
- Exploring effect of changing valuation with income
  - At what point would reducing ozone benefit the high incomes instead of low incomes (how much would valuations have to increase with income?)

## Future Work

- Effect of CO<sub>2</sub> reductions from existing power plants on air quality:
  - Use new state-level economic model to explore the effect state-level caps vs. regional trading
  - Can the size of the trading region create a tradeoff between the total health benefits, and the potential creation of pollution hotspots?

# Acknowledgments

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A photograph of a forest stream with moss-covered rocks and a fallen log. The water is flowing over the rocks, creating small cascades. The scene is surrounded by dense green foliage and trees.

**QUESTIONS?**

A scenic view of a stream flowing over moss-covered rocks in a forest. A large log bridge is visible in the background. The water is clear and flows over the rocks, creating small cascades. The moss is a vibrant green, and the surrounding trees are lush and green.

**THANK YOU!**