Future Year Attainment Modeling in North Carolina: An alternative look at health-related benefits

Sarav Arunachalam and Andrew Holland

Sarav@email.unc.edu

Presented at the
4th Annual CMAS Models-3 Users Conference

September 26-28, 2005

[1]Carolina Environmental Program, UNC-CH

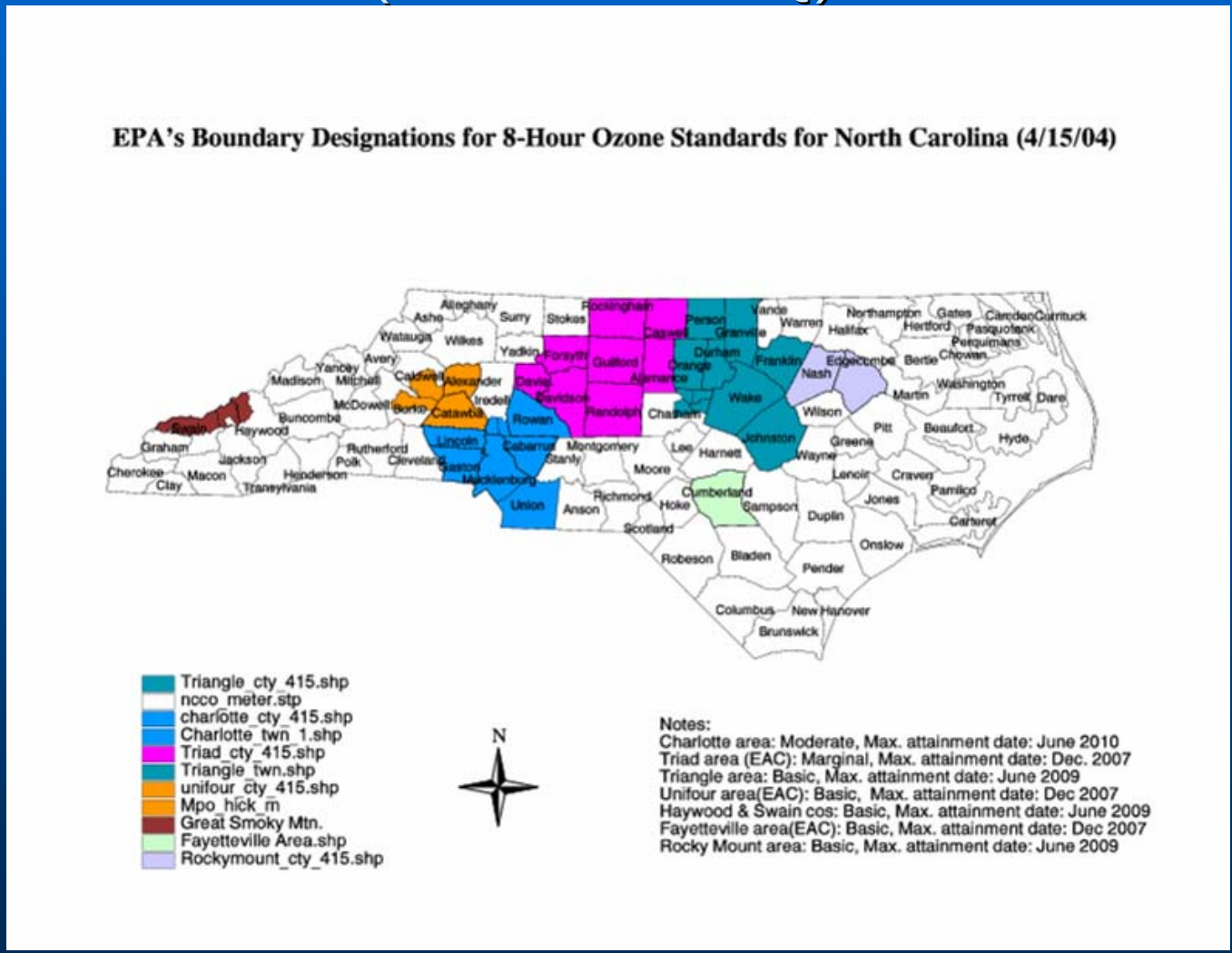
Objective

- Evaluate population exposure-based or health-related benefits from modeled attainment demonstration in North Carolina

Motivation

- Does modeled attainment demonstration help protect the population in the studied region?
  - *".. Increasing evidence that there might not be an identifiable exposure concentration for some criteria pollutants below which human health effects would cease to occur"*, National Research Council, 2004

Background
(Source: NCDAQ)



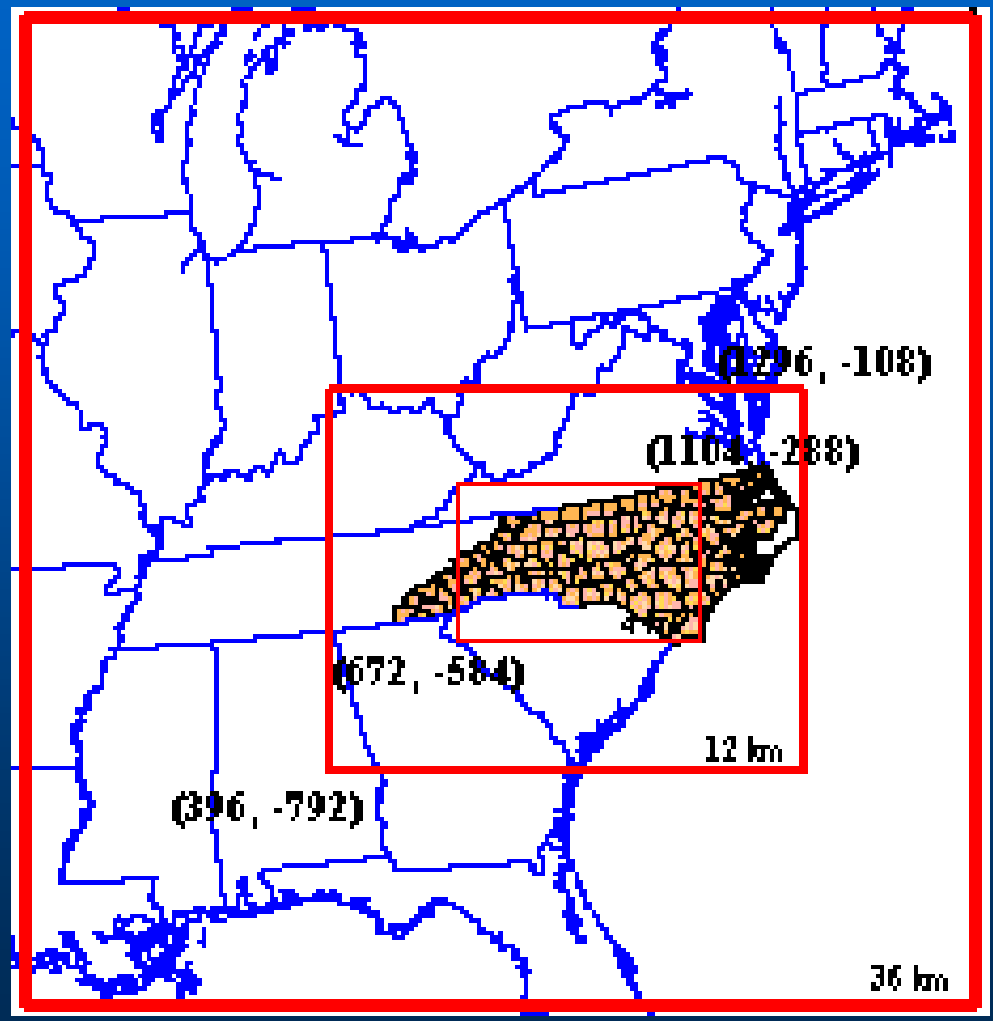
Approach

- Develop base case model application for 8-h ozone
- Perform model simulations for base year (2000) and future years (2007, 2012, 2017)
- Apply U.S. EPA's Draft Guidance for modeled attainment demonstration (USEPA, 1999)
- Test for attainment in future years
- Obtain population data for modeled years
- Compute "potential population exposure" estimates
- Use BenMAP to perform health benefits analyses

Modeling Systems

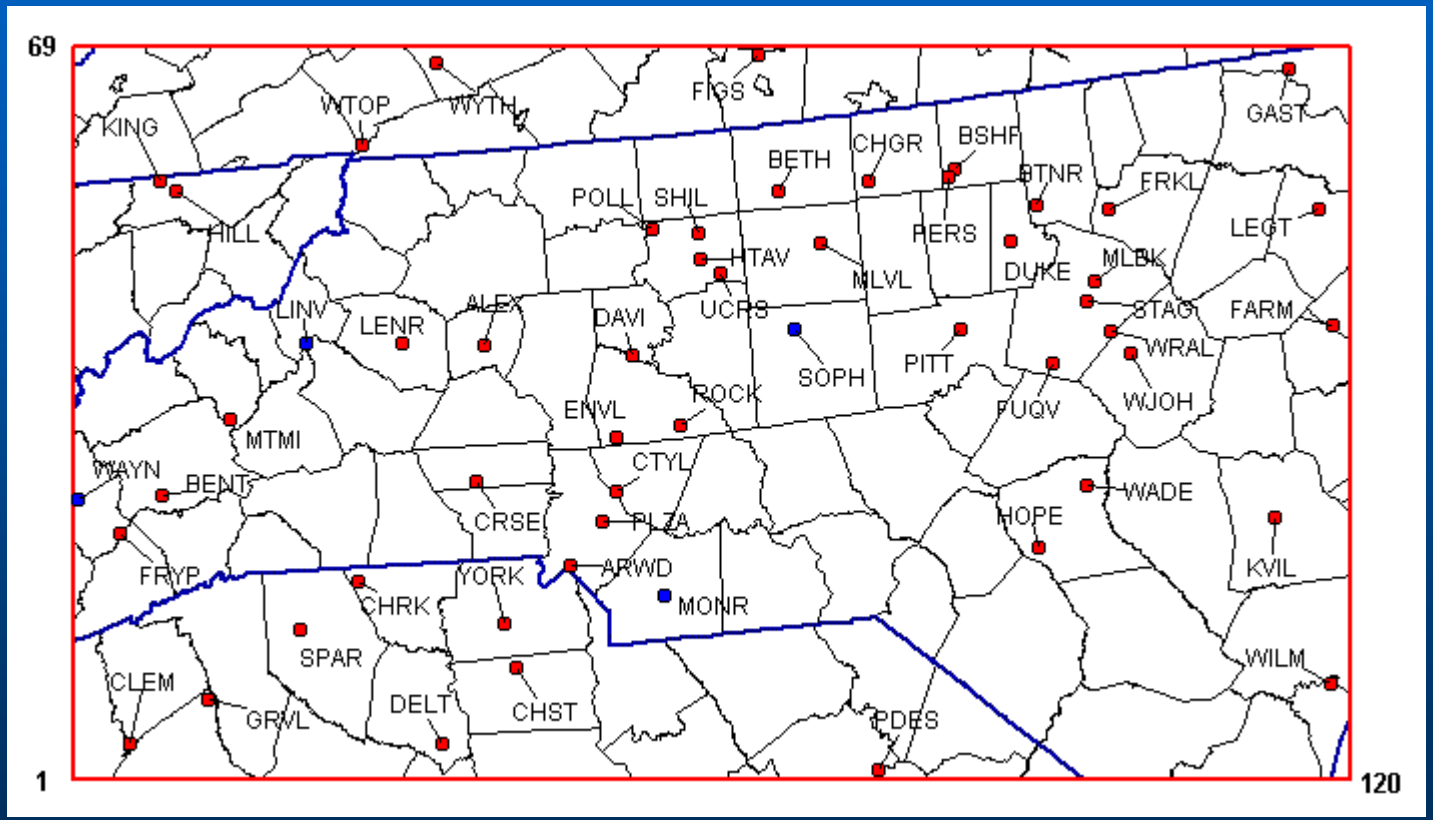
- Fifth-Generation Penn State/NCAR Mesoscale Model (MM5)
- Sparse Matrix Operator Kernel Emissions (SMOKE)
- Multiscale Air Quality SImulation Platform (MAQSIP) (Prototype to Models3/CMAQ)
- Four 8-h Ozone Episodes in North Carolina
  - July 12-15, 1995
  - June 21-24, 27-30, 1996
  - July 12-15, 1997
- Total of 16 episode days analyzed
- Nested grids at 36 / 12 / 4-km resolution

Nested Modeling Domain



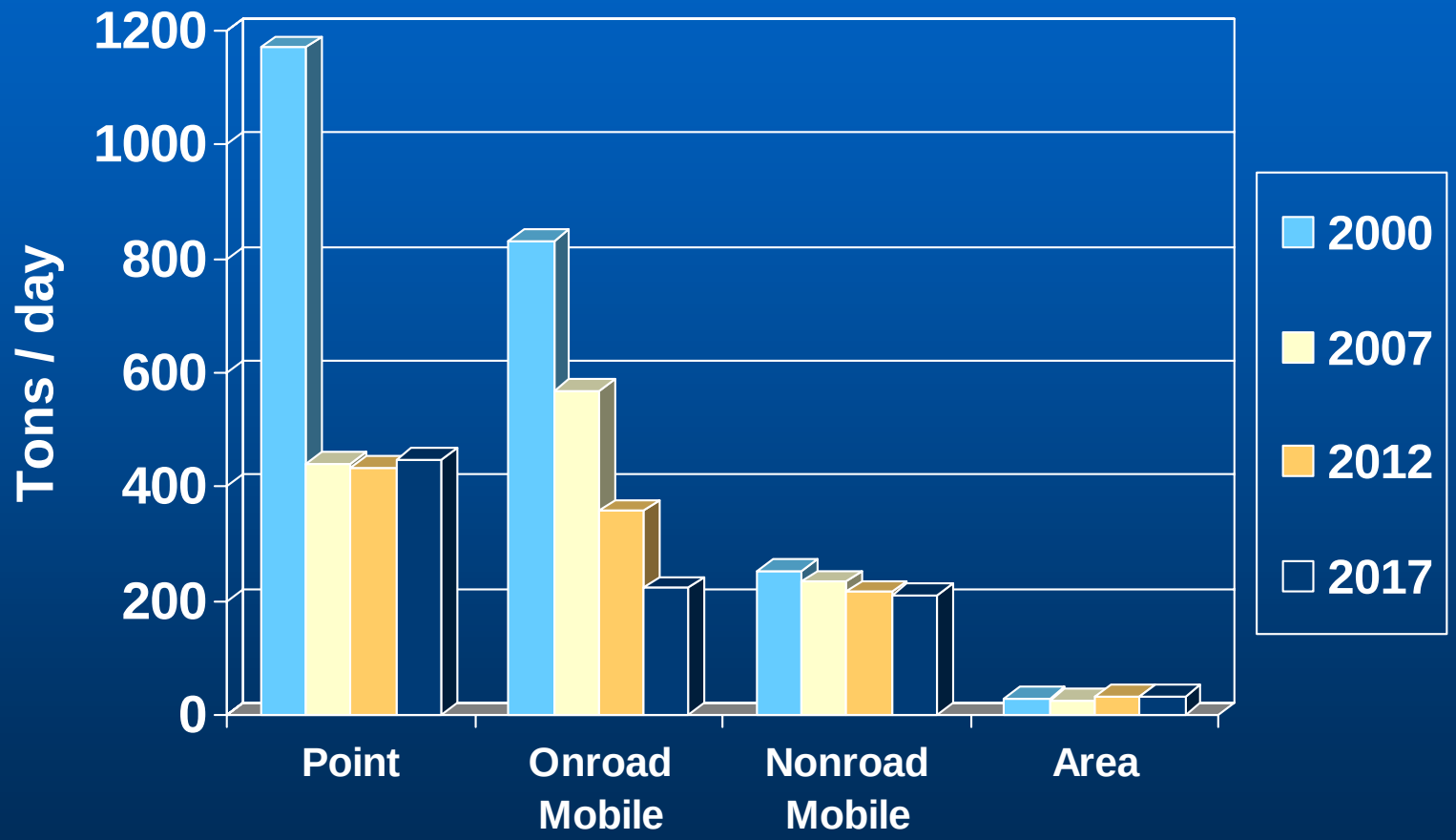
UNC CAROLINA ENVIRONMENTAL PROGRAM

Monitors in 4-km Grid



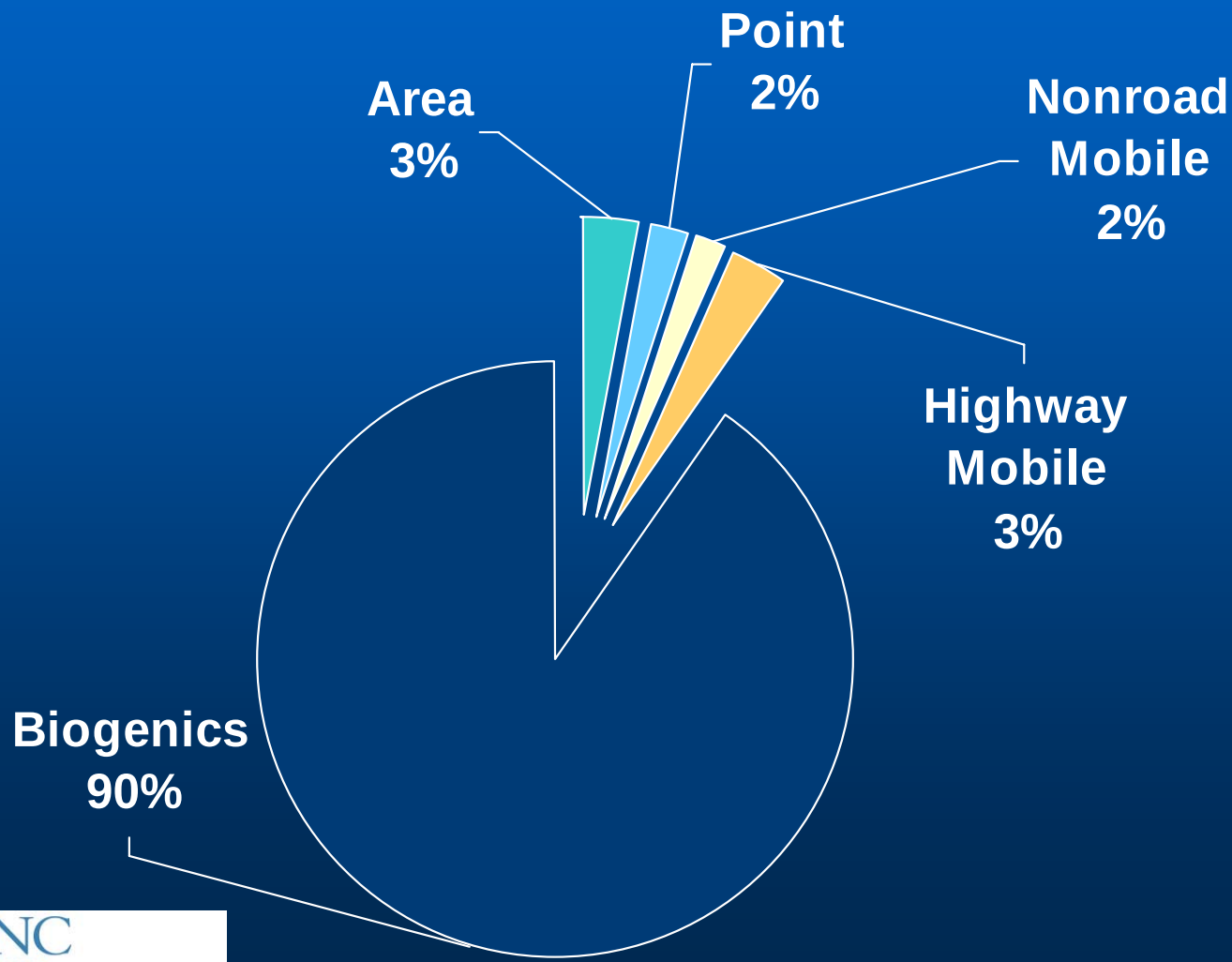
UNC CAROLINA ENVIRONMENTAL PROGRAM

NO_x Emissions in NC



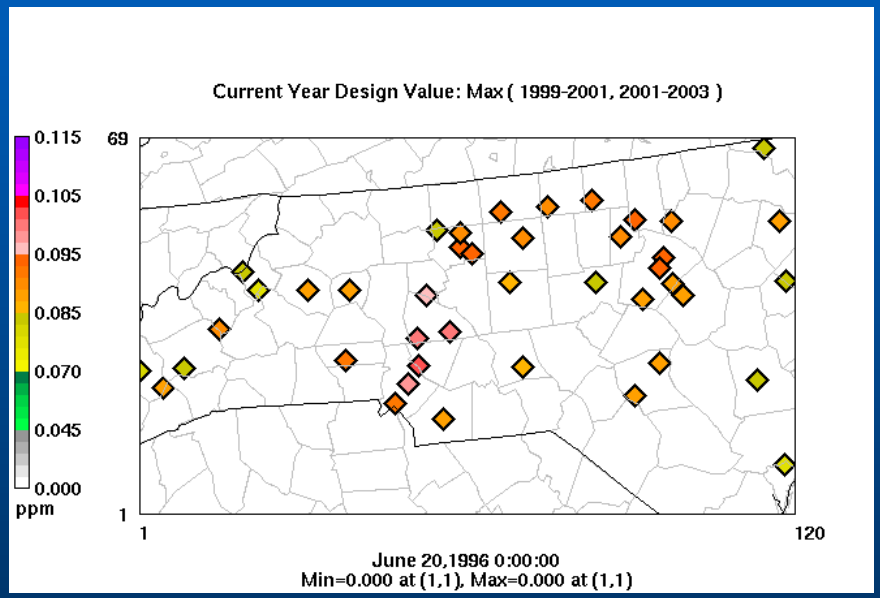
UNC CAROLINA ENVIRONMENTAL PROGRAM

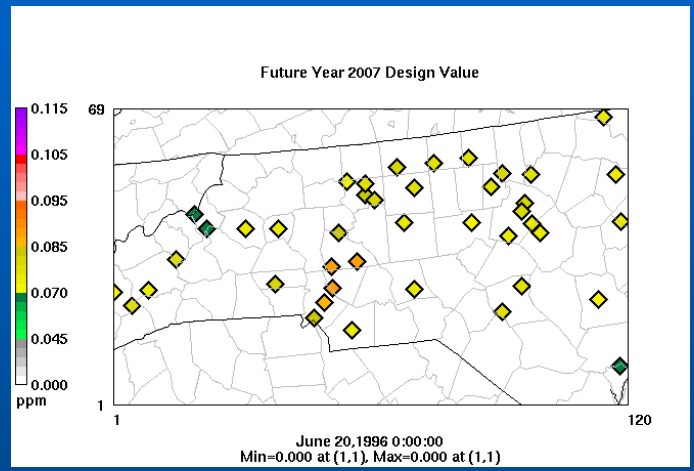
2000 VOC Emissions in NC (14,028 Tons / day)

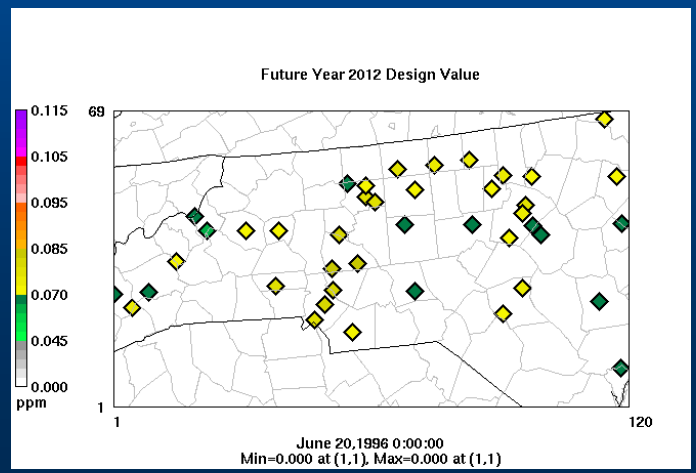


UNC CAROLINA ENVIRONMENTAL PROGRAM

8-h Ozone Design Values
(2000, 2007, 2012)

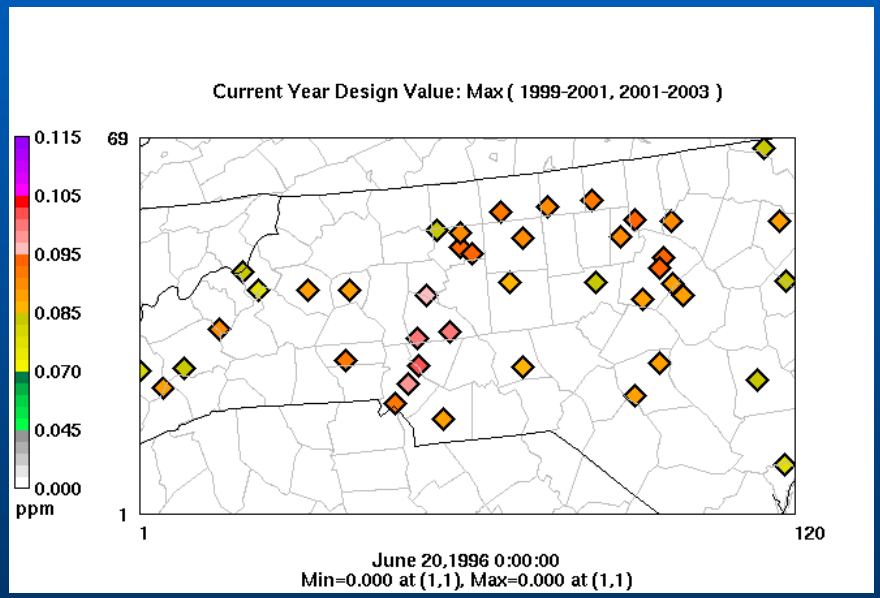


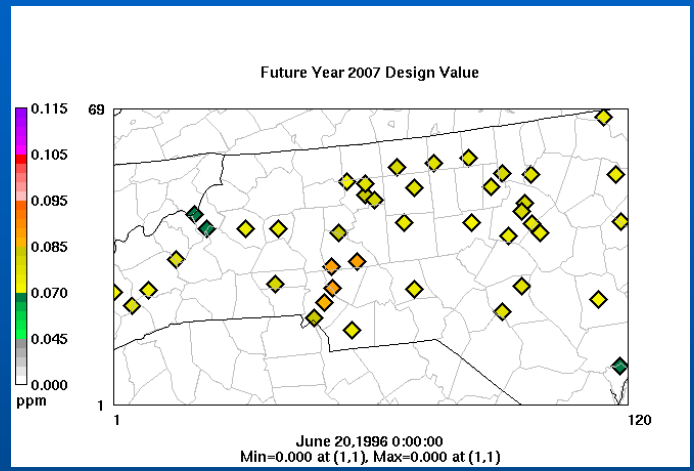


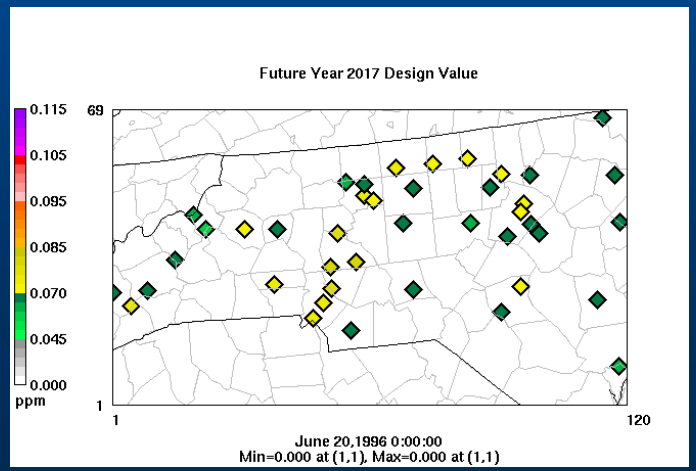


UNC CAROLINA ENVIRONMENTAL PROGRAM

8-h Ozone Design Values
(2000, 2007, 2017)







UNC CAROLINA ENVIRONMENTAL PROGRAM

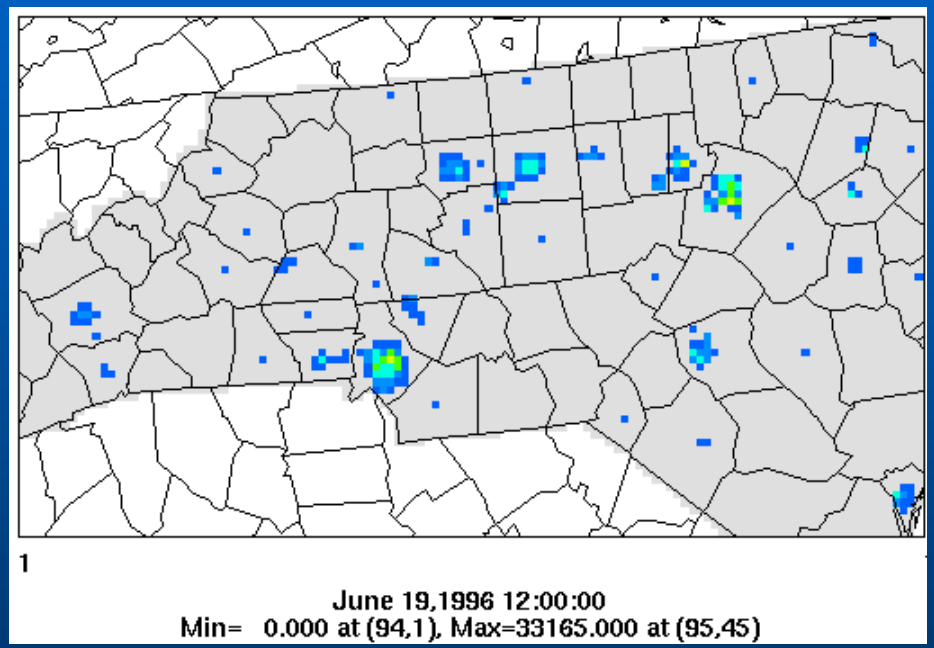
8-h Ozone Design Values (Charlotte MSA)

	DVC	2007 DVF	2012 DVF	2017 DVF
CountyLine	0.101	0.087	0.080	0.076
Rockwell	0.100	0.087	0.082	0.079
Enochville	0.099	0.088	0.083	0.079
Garinger	0.098	0.085	0.079	0.075
Crouse	0.092	0.080	0.078	0.074
Arrowood	0.092	0.082	0.077	0.073
Monroe	0.088	0.075	0.070	0.067

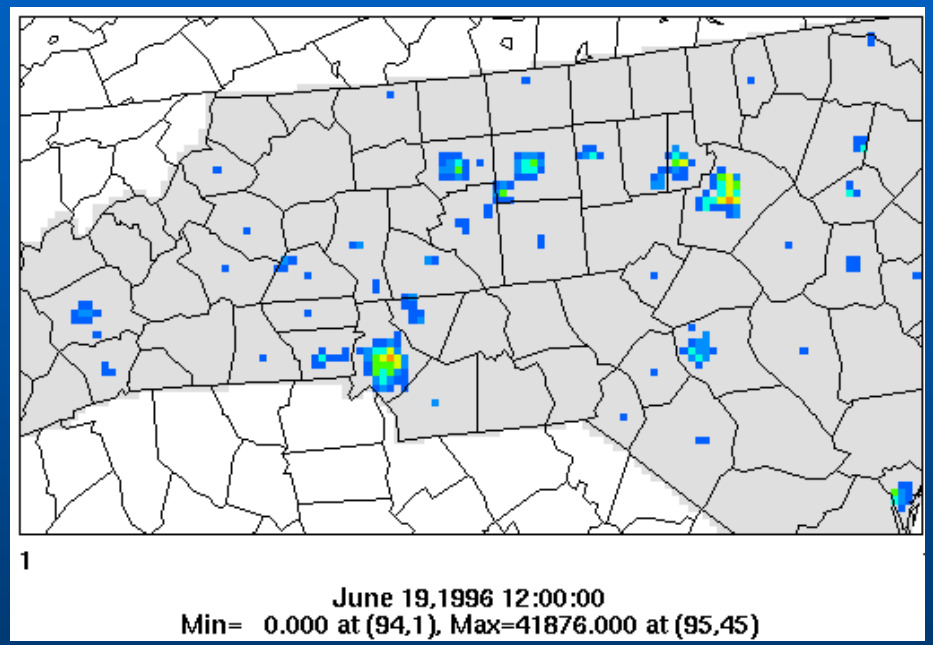
Potential Population Exposure

- Obtain baseline population estimates for North Carolina counties for 2000
- Obtain projections for future years modeled, i.e., 2007, 2012 and 2017
  - Source: NC State Data Center
  - http://demog.state.nc.us
- Perform gridding of population data to 4-km domain using surrogates
- Potential Population Exposure
  - Distributed metric defined as $P_E(c > c', t > t')$

Gridded Population Estimates

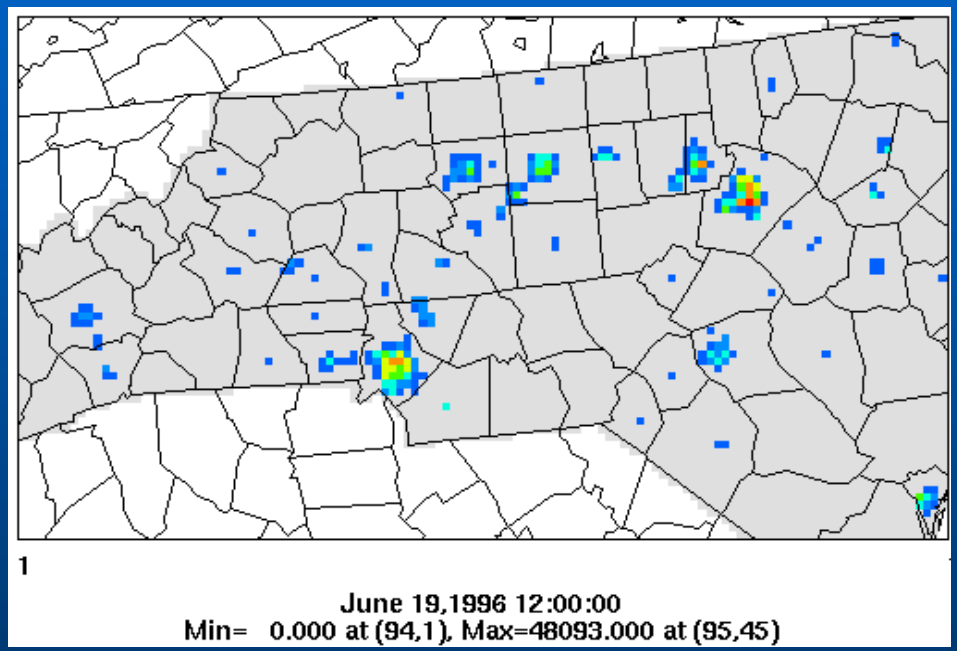


2000

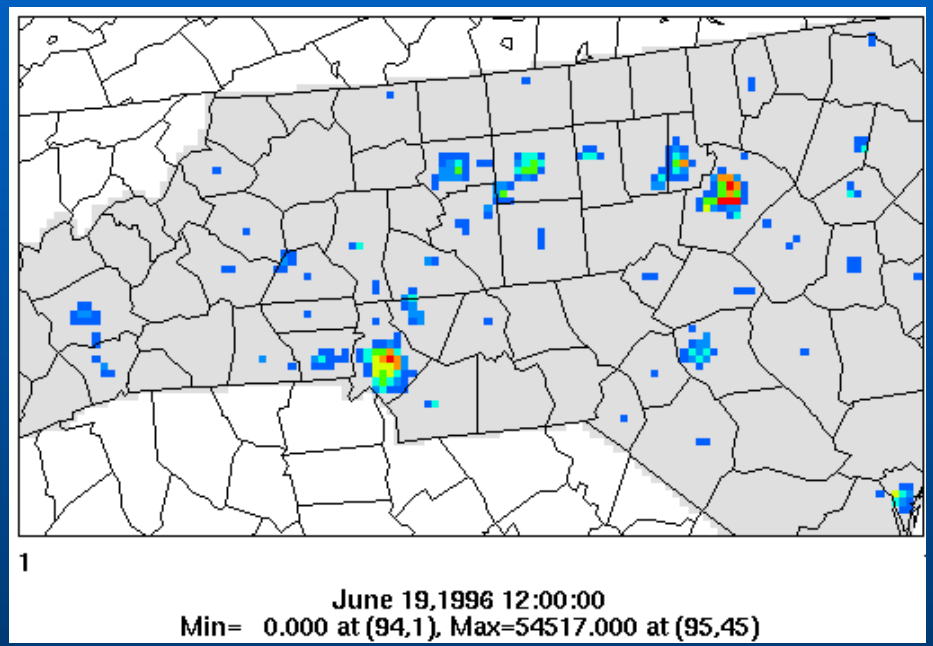


2007

Gridded Population Estimates

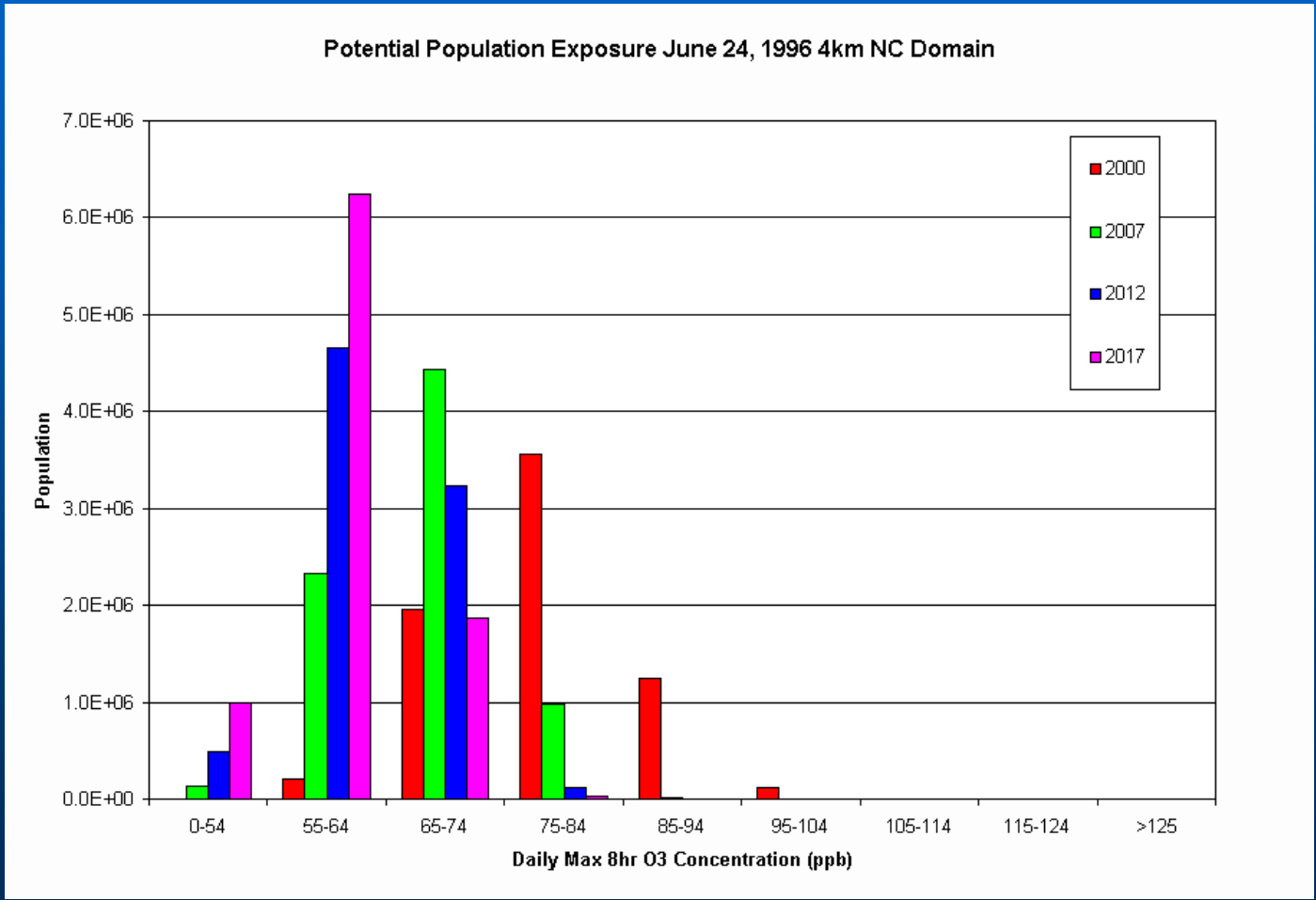


2012



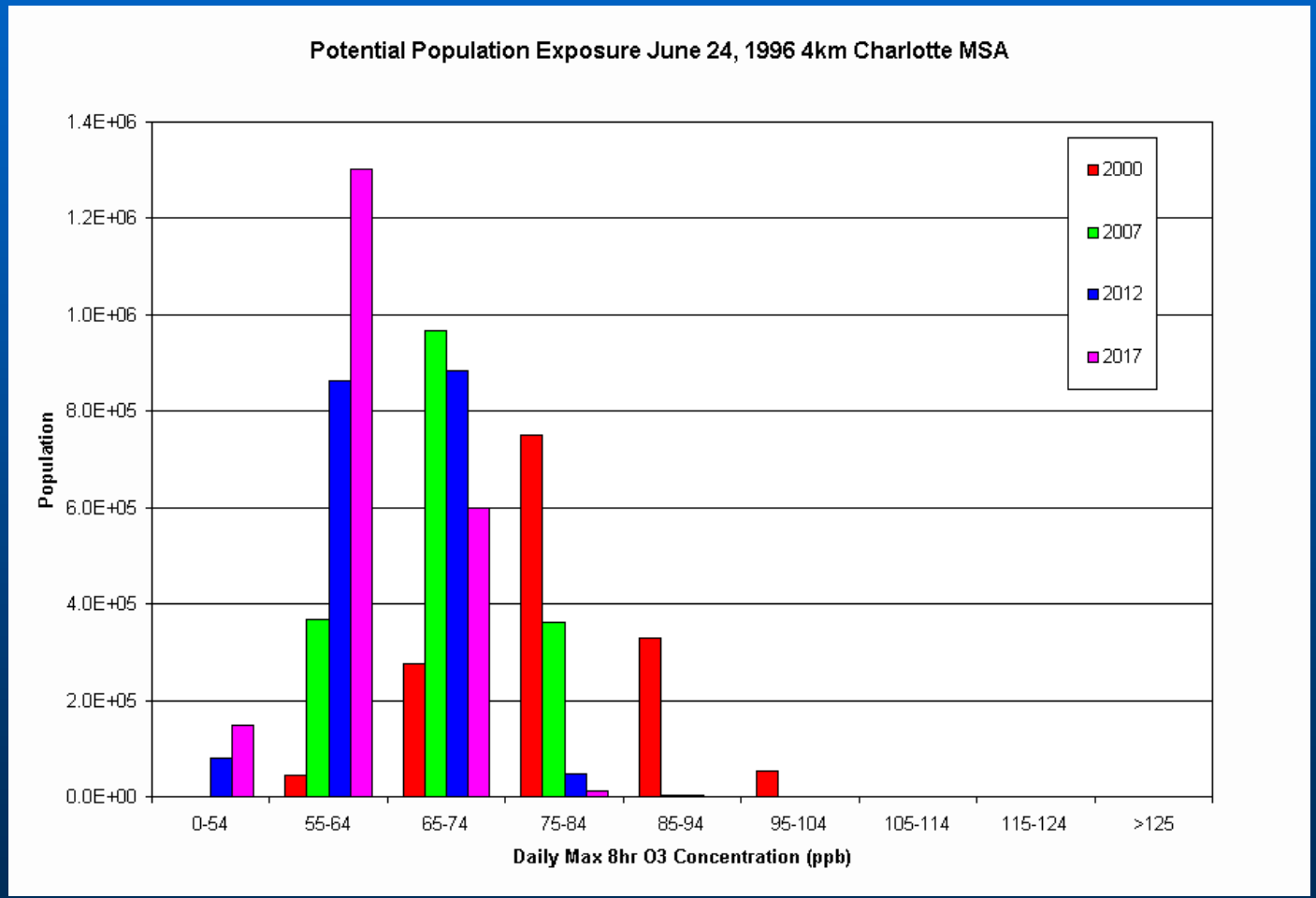
2017

Potential Population Exposure
All of NC on 6/24/96



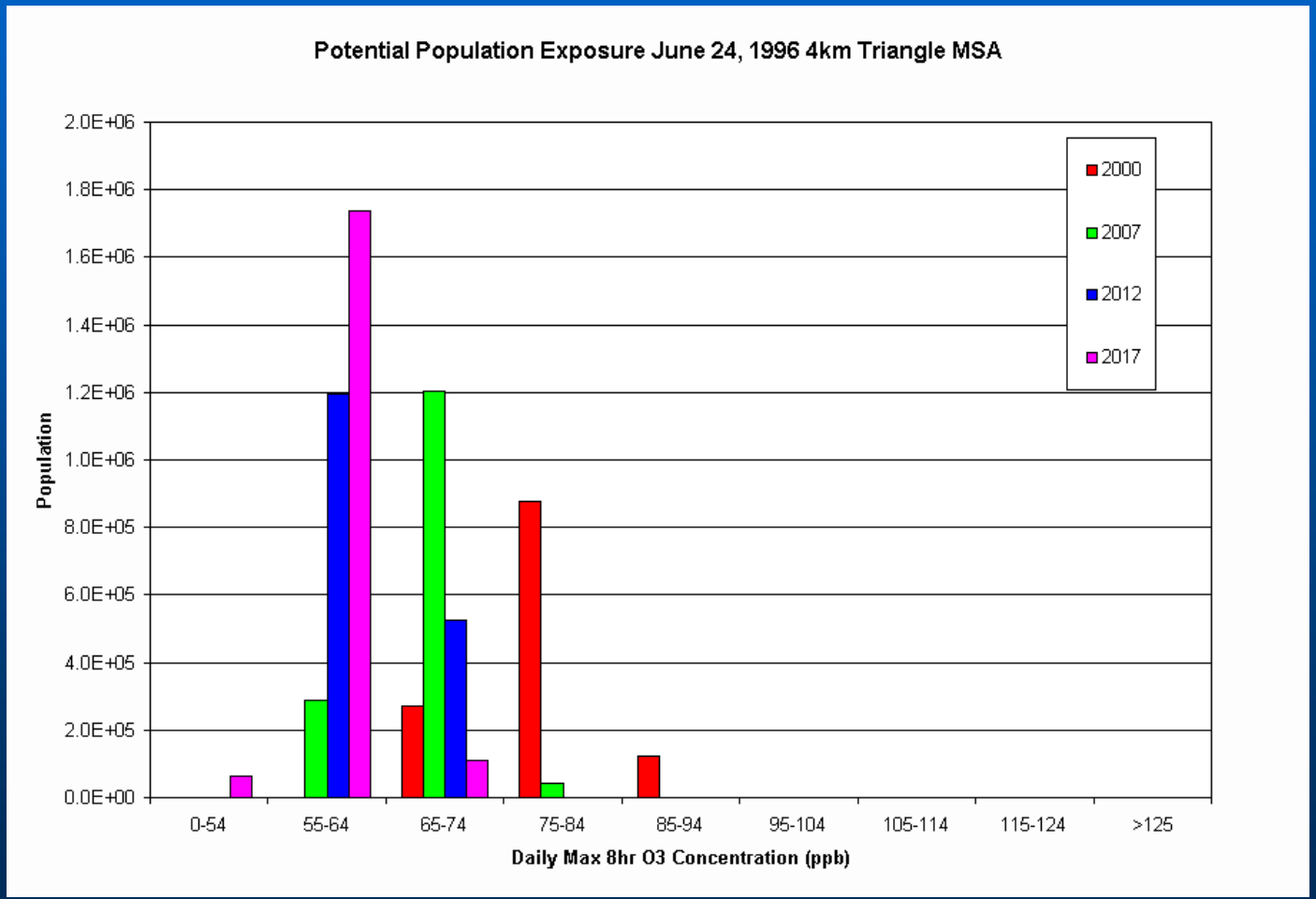
UNC CAROLINA ENVIRONMENTAL PROGRAM

Potential Population Exposure Charlotte MSA on 6/24/96



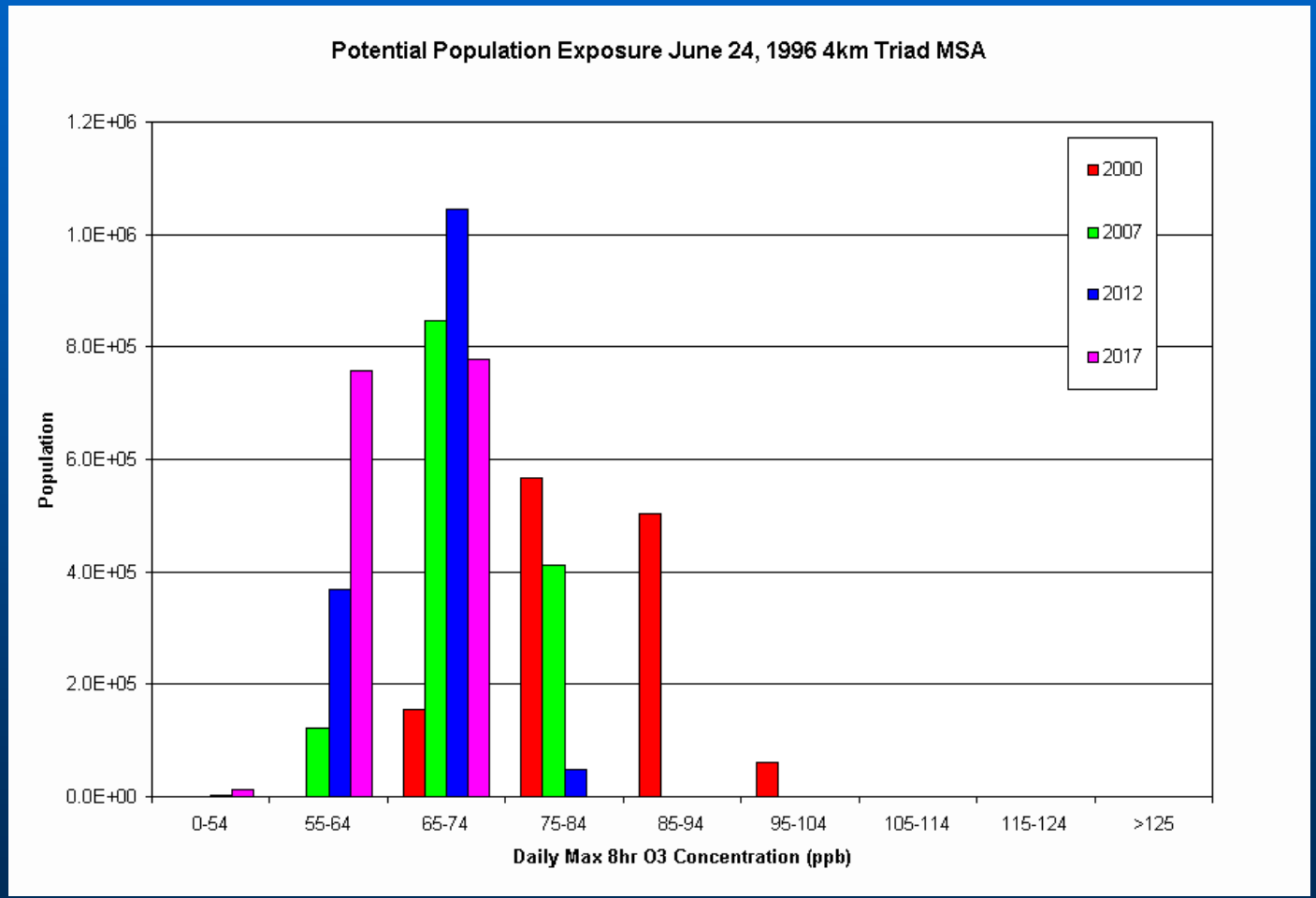
UNC CAROLINA ENVIRONMENTAL PROGRAM

Potential Population Exposure Triangle MSA on 6/24/96



UNC CAROLINA ENVIRONMENTAL PROGRAM

Potential Population Exposure Triad MSA on 6/24/96



UNC CAROLINA ENVIRONMENTAL PROGRAM

BenMAP

- BenMap – Environmental Benefits Mapping and Analysis Program
- Primarily intended as tool for estimating health impacts, and associated economic values
  - Used by EPA to evaluate benefits of various rulemakings
- Uses health-impact functions to relate changes in concentrations to change in incidence of a health endpoint
- E.g., Mortality Change = Change in Concentration * Mortality Effect Estimate * Mortality Incidence * Exposed Population

BenMAP Application

- Obtained data for ozone-related health-based end-points
  - Acute respiratory symptoms
  - Emergency Room visit due to respiratory symptoms
  - Hospital admission due to all respiratory symptoms
  - Hospital admission due to asthma alone
- Data based upon epidemiologic studies in other North America cities (no data for North Carolina)
- Applied modeled concentration data to these end-points
- Work in progress

Discussion

- Applied guidance for modeled attainment demonstration for 4 8-h O_3 episodes in NC
- Except 4 sites in Charlotte, all other sites in NC attaining in 2007
- All sites in NC attaining in 2012 and 2017
- Extended analyses using “potential population exposure” metric based upon population data for modeled years
- While simplistic, this metric could be useful for rationalizing priorities for emissions reductions
- While O_3 levels are decreasing in future years, the potential population exposure metric is increasing at lower O_3 thresholds

Future Work

- Obtain data for population sub-classes (based upon age/sex/race) and diurnal activity data, to extend the potential population exposure metric
- Continue BenMAP analyses to evaluate health-related benefits
- Use NC specific health incidence data
  - New NCER Grant to UNC to study effects of climate change on human health

Acknowledgements

- North Carolina Department of Environmental and Natural Resources
- Bryan Hubbell, USEPA-OAQPS
- Aaron Hallberg, Abt Associates