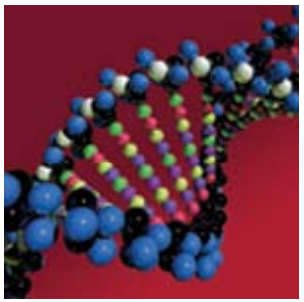
An Emission Inventory for Natural Gas Development in the Haynesville Shale and Evaluation of Ozone Impacts


19th International Emission Inventory Conference

September 28, 2010

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Jaegun Jung, Wilson Santamaria, and Greg Yarwood
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The Haynesville Shale

Figure from the Wall Street Journal, July, 2008

- 10,000-13,000 feet below surface
- 300' thick layer of sedimentary rock
- May be one of largest natural gas reserves in the U.S.
- First highly productive wells drilled in 2008

Ozone Air Quality Implications

Counties with Ozone Monitors Violating Potential Primary Ozone Standard

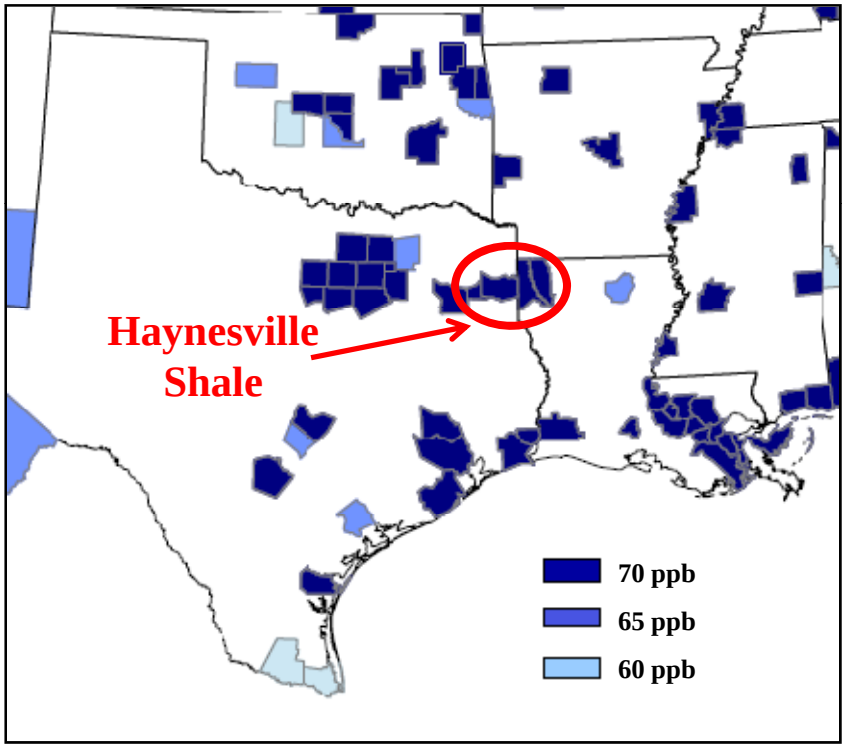


Figure: U.S. EPA, http://www.epa.gov/air/ozonepollution/pdfs/20100104maps.pdf

- Haynesville Shale development economically important
- Release of ozone precursor emissions within/upwind of potential ozone non-attainment areas
- Lower 2010 ozone standard enhances importance of understanding impacts of Haynesville Shale on regional ozone

Emissions from Exploration

Figure from geology.com

Figure from http://www.axpc.us/field/index.html

- Drilling, completion, fracing

Horizontal Drilling and Hydraulic Fracturing

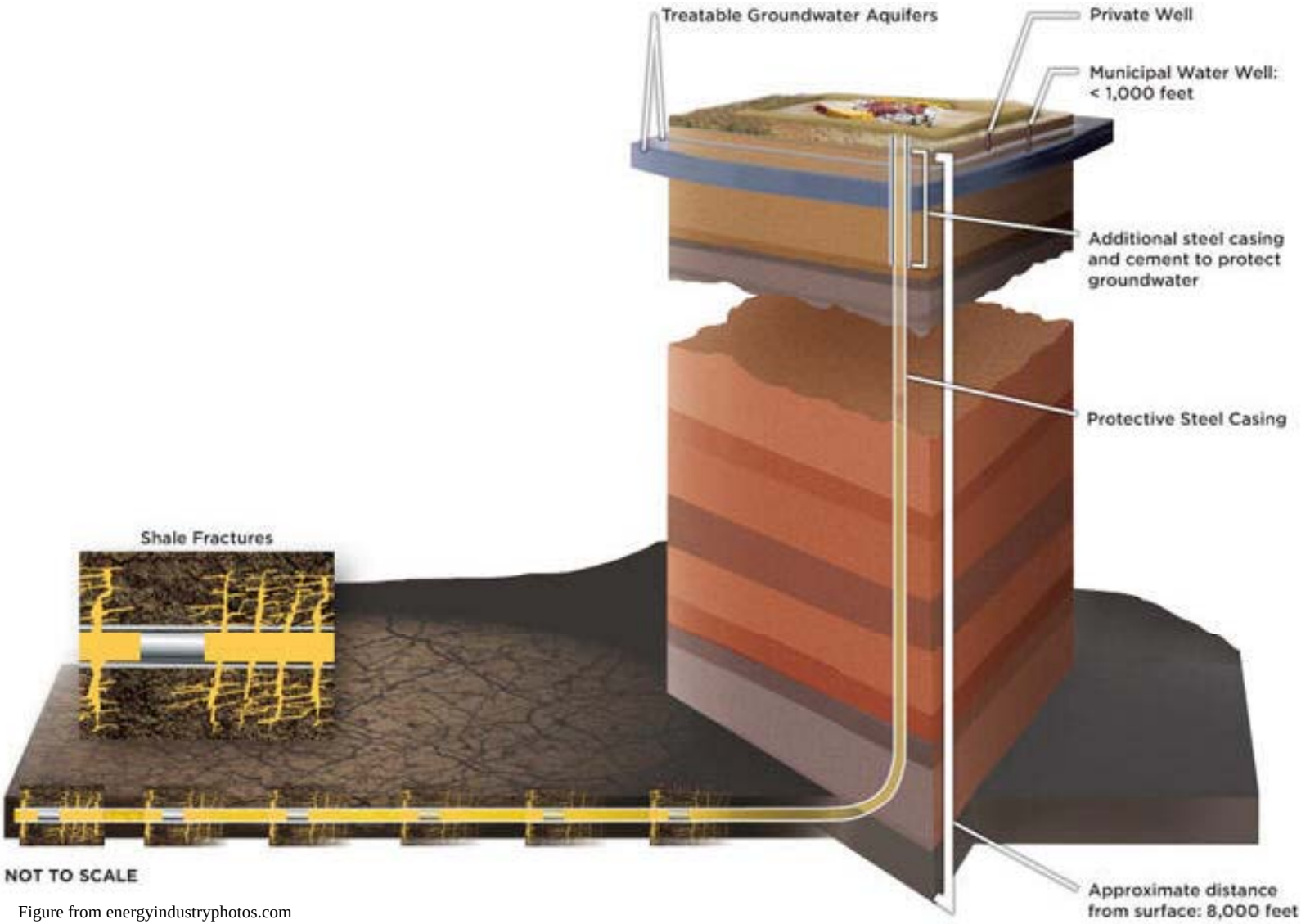


Figure from energyindustryphotos.com

Emissions from Production

www.linde-engineering.com

- Well site equipment
- Compression at wellhead and central stations
- Gas processing plants

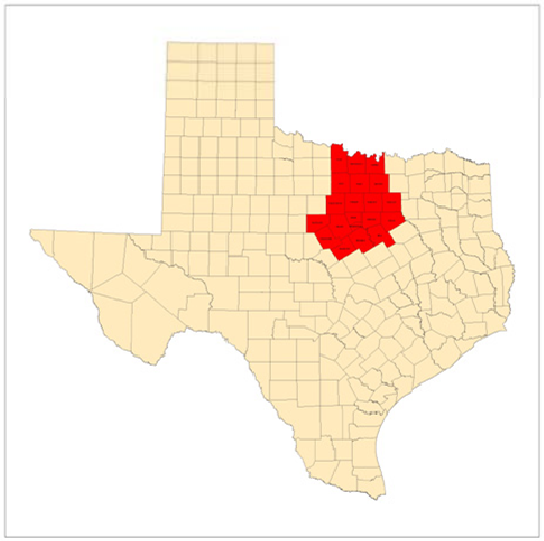
Study of Haynesville Development

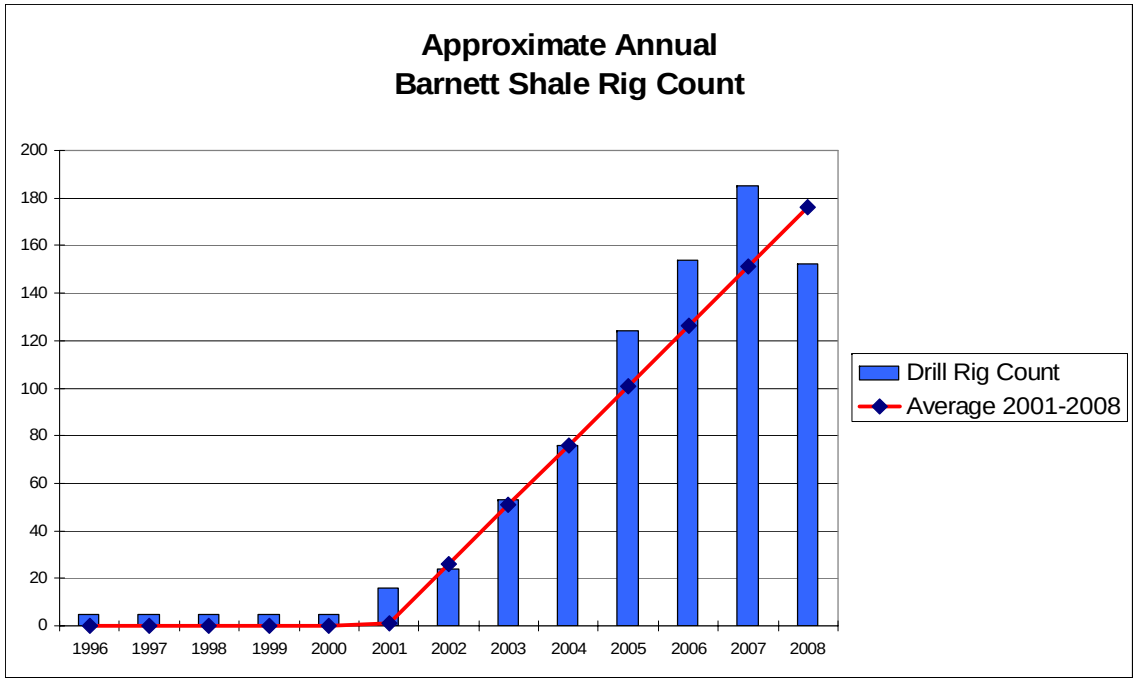
- Estimate future development to 2020
- Calculate associated emissions of ozone precursors
- Model ozone impacts in 2012
- Study performed in 2009-new information now available

Projecting Future Development and Emissions

- Future year activity based on
  - Number of new wells drilled each year
  - Well productivity
- Allows calculation of formation-wide
  - Well count
  - Gas production
- Once well count and gas production are forecast, can develop an emission inventory for exploration and production activity for the entire Haynesville Shale

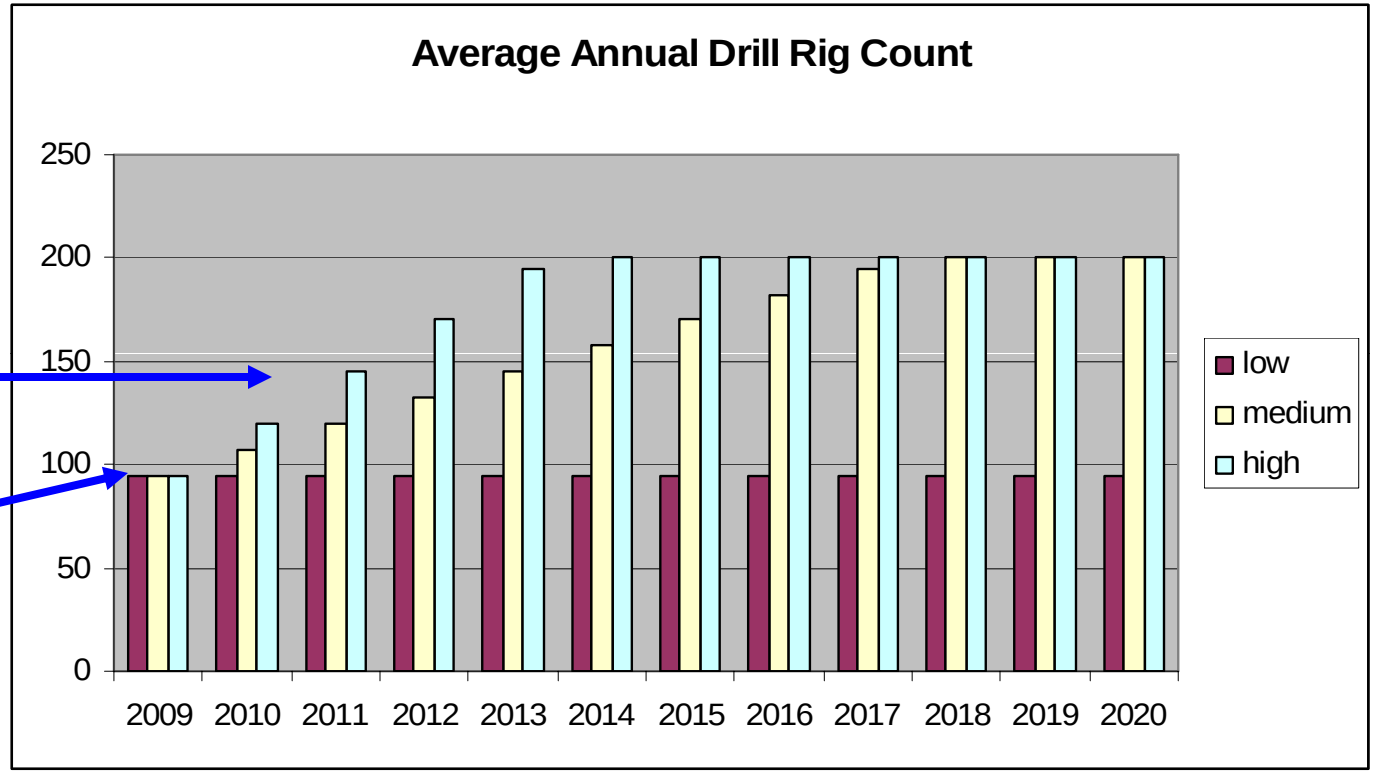
Projecting Future Activity





- Use historical growth from Barnett Shale to estimate future growth in the Haynesville Shale
- Forecasts of future Haynesville production (8-35 TCF) using this method fall within range of estimates of total recoverable reserves

Drill Rig Projections: 3 Scenarios

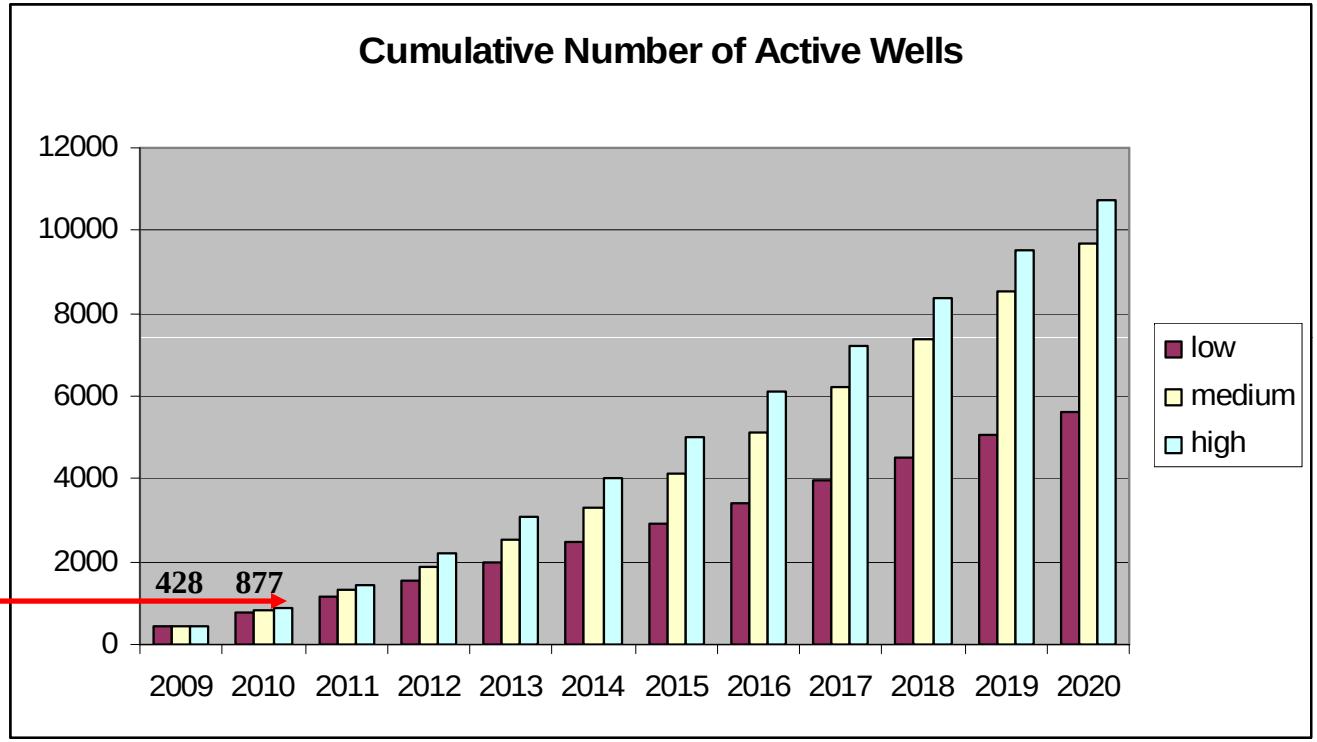


Sept. 2010 ~145 Rigs

March 2009 95 Rigs

- Low scenario: leave March 2009 drill rig count fixed
- High scenario: use 2001-2008 Barnett Shale rig count growth, cap growth at 200 rigs
- Moderate: 50% of high scenario

Well Number Projections

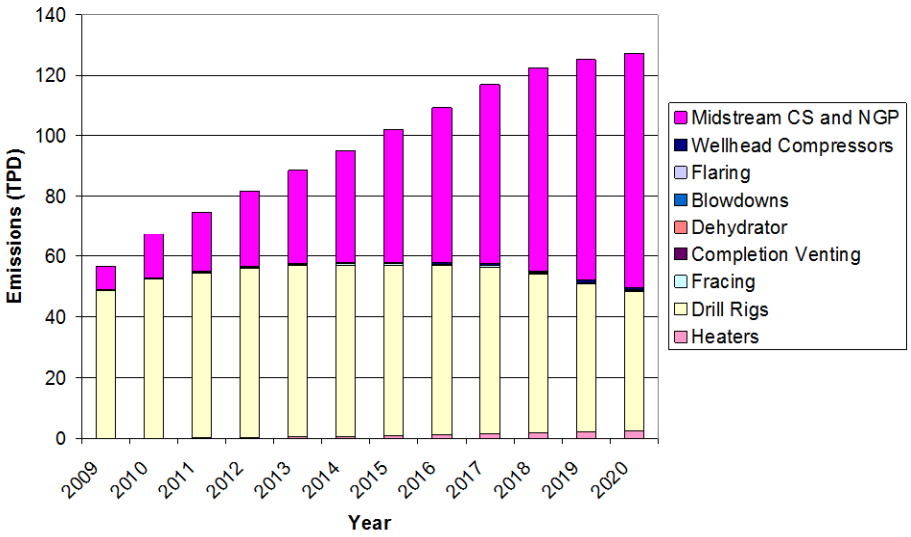


904 producing wells as of Sept. 2010

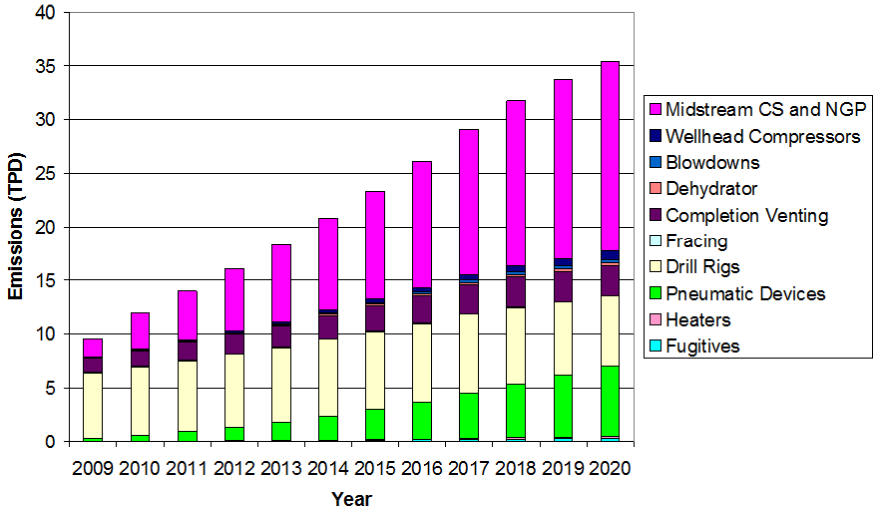
- Texas: 296 active Haynesville wells, 458 permitted (TRRC)
- Louisiana: 608 producing wells, 124 being drilled, 499 other (completion/frac/testing), 311 permitted not yet drilling, 1542 total Haynesville wells (LDNR)

Formation-Wide Emissions: Moderate Scenario

NOx Emissions



VOC Emissions



- Gas processing plants, compressor stations, drill rigs are important sources of NOx and VOCs
- Drill rig emissions fall off after 2017 due to controls
- Haynesville development likely to continue past 2020

Projected Haynesville Shale NOx Emissions

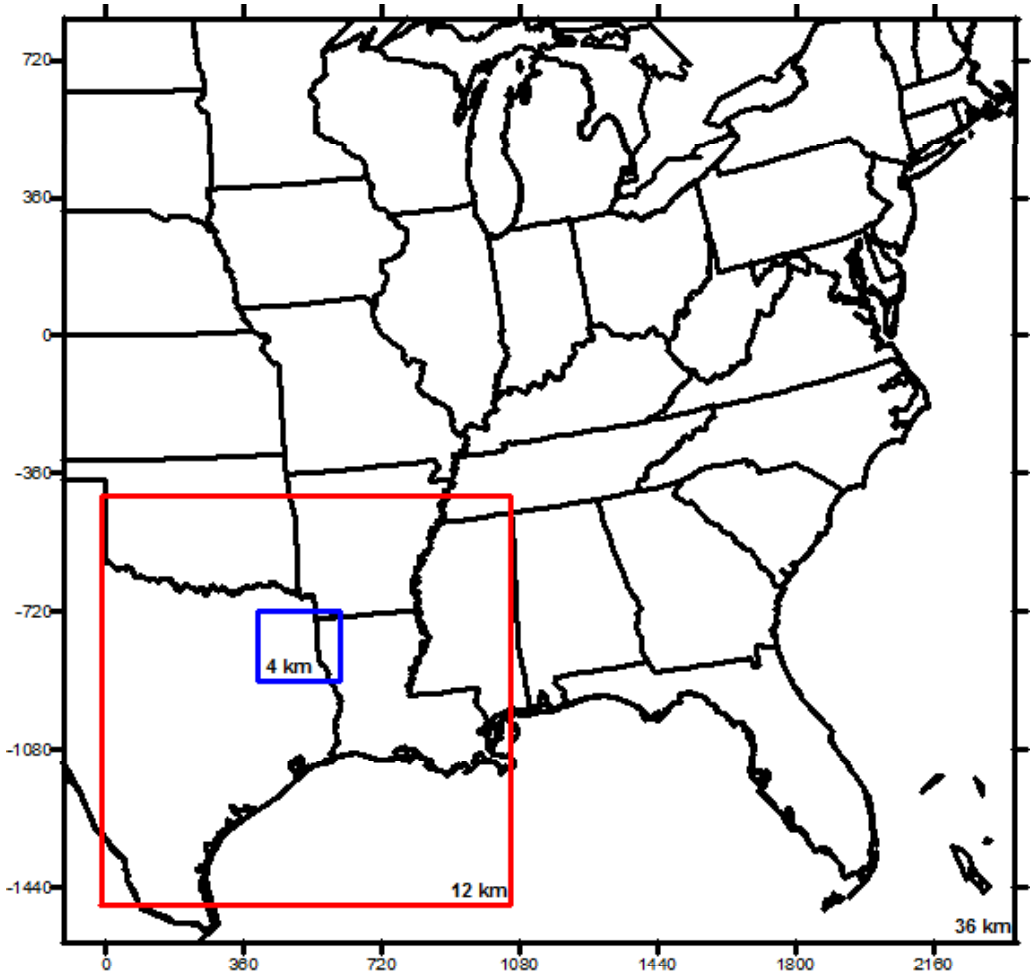
Forecast
NOx Emissions (Tons/Day)

Scenario	2012	2020
Low	61	64
Medium	82	127
High	140	267

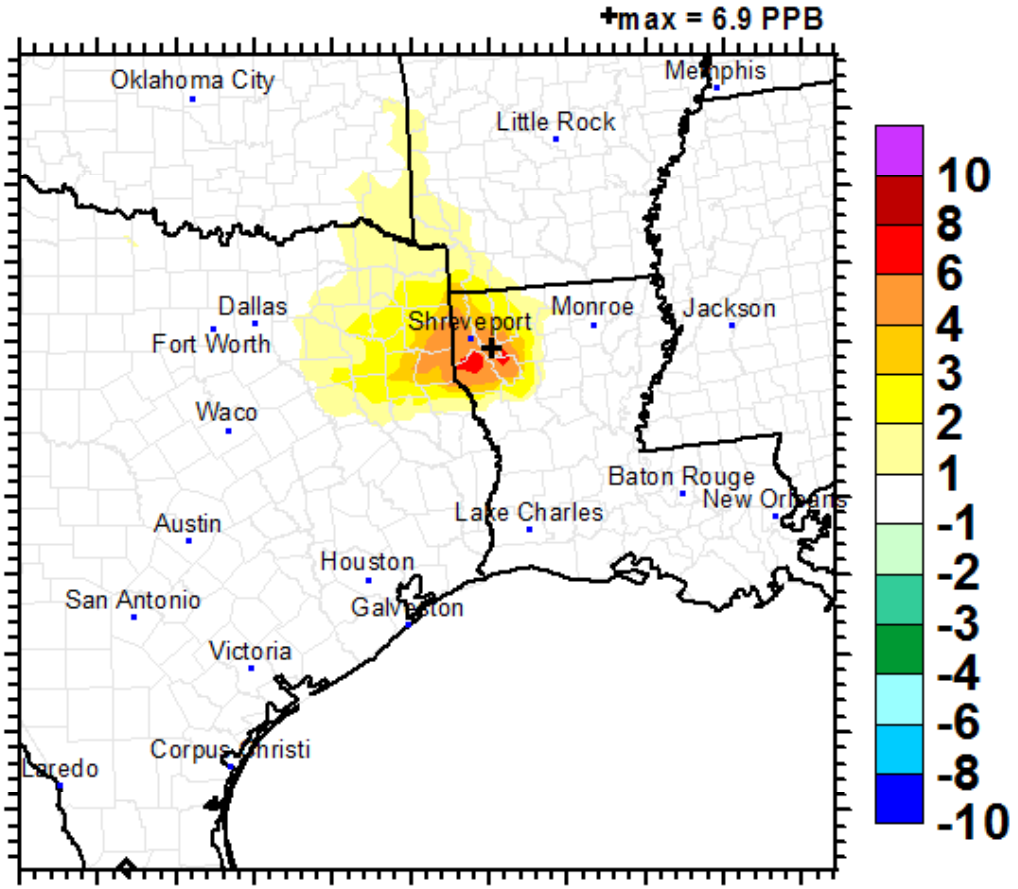
- Perspective: 50 tons/day roughly equivalent to NOx emissions from a large, coal-fired power plant

CAMx Ozone Model

- May-June 2005 high ozone episode, MPE
- Future year scenarios:
  - FY 2012 base case with no Haynesville emissions
  - FY 2012+Haynesville high, medium and low emissions scenarios
- HS Impacts (High) = Haynesville High – 2012 Base Case
- Focus on 8-hour ozone impacts
  - Show high scenario only

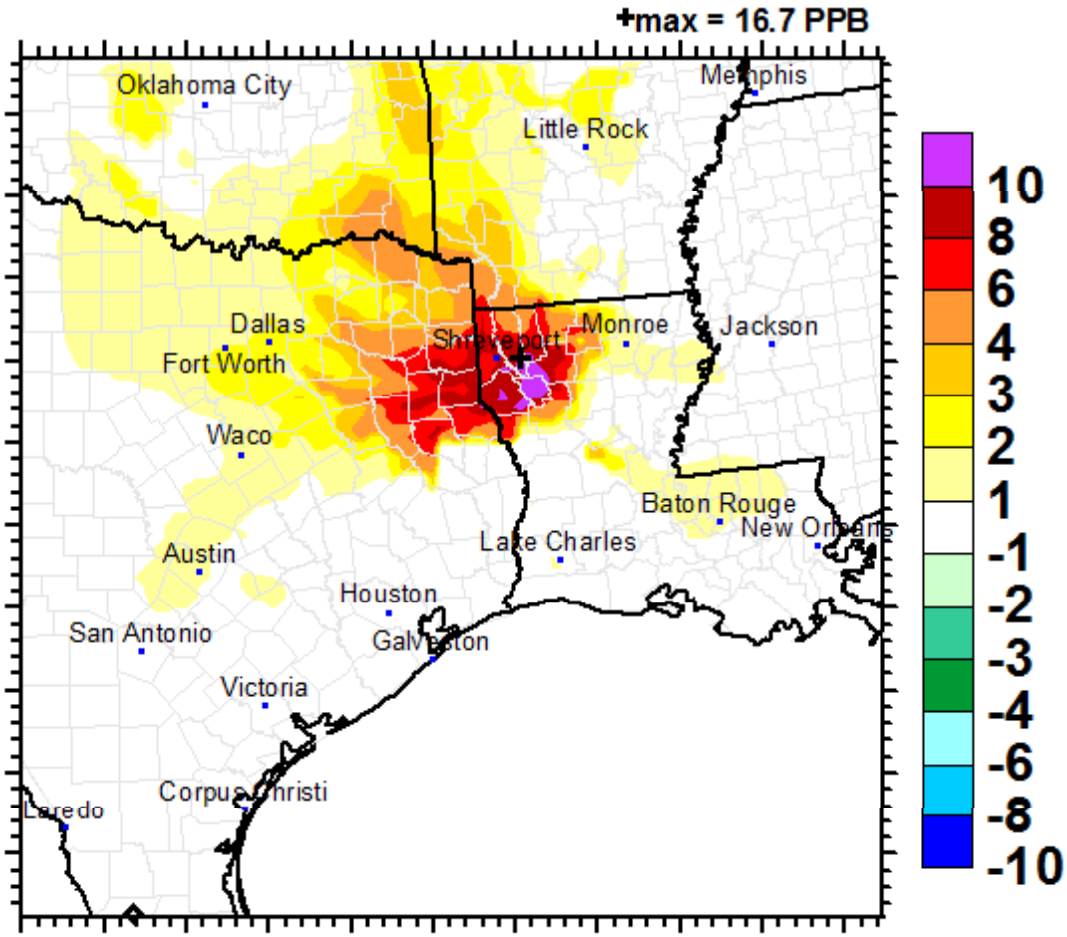


Average Regional 8-Hour Ozone Impacts in 2012



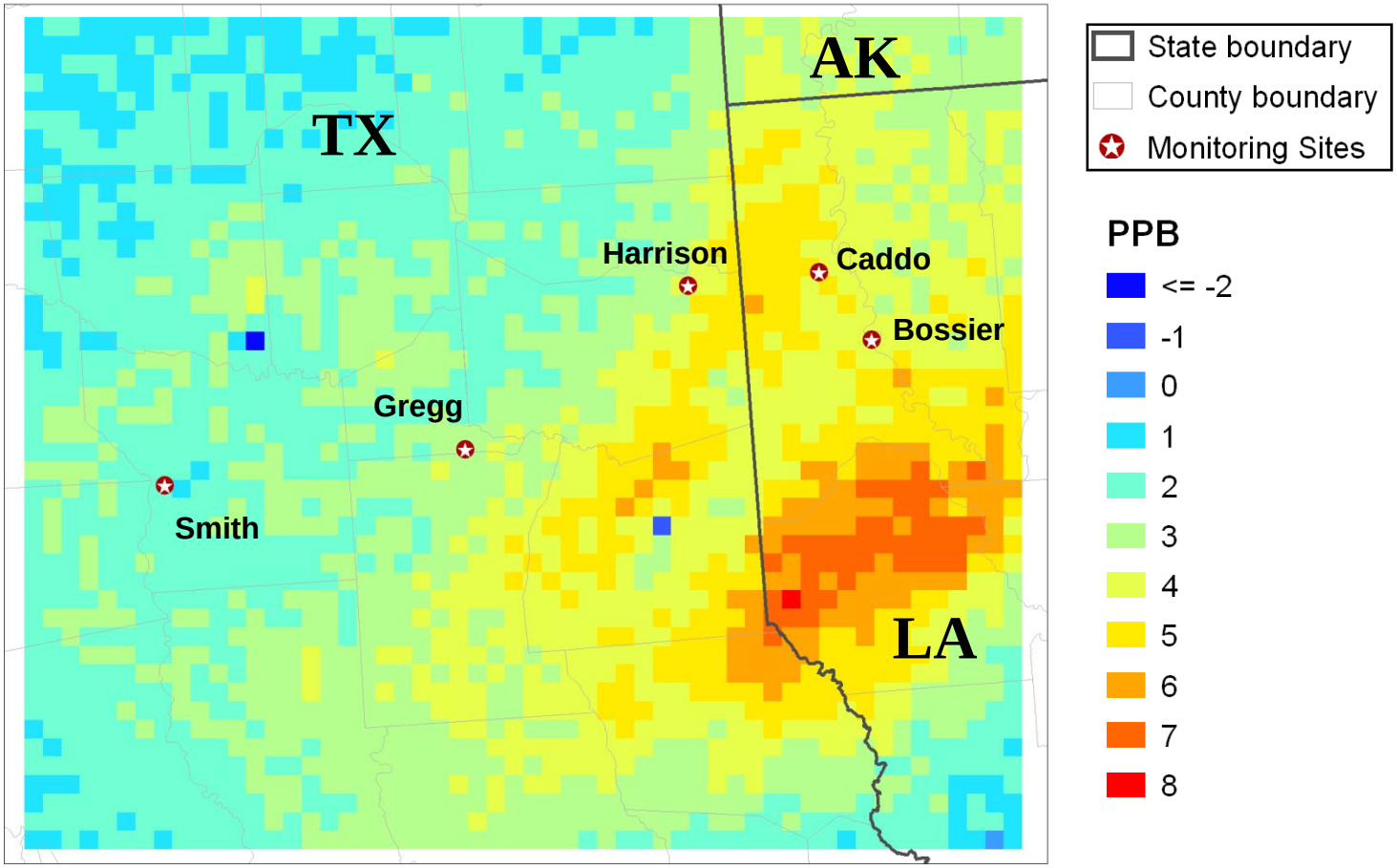
- Average impacts > 1 ppb restricted to Northeast Texas, Louisiana, Arkansas and Oklahoma

Maximum Regional 8-Hour Ozone Impacts in 2012



- Maximum impacts extend outside Northeast Texas into other regions of Texas

Ozone Design Value Impacts in 2012



- Design values increase 4-5 ppb at Louisiana monitors
- 4 ppb increase at Harrison, TX monitor
- Smaller increases (1-2 ppb) at Gregg and Smith monitors in TX

Summary

- Haynesville Shale development is a concern for future regional air quality
- Early estimates presented here are uncertain
  - May underestimate NOx because assumed little well-head compression
  - May over- or underestimate emissions for other reasons
- Additional study is planned and will benefit from more data regarding well site compression, well decline curves, etc.
  - Input from energy companies would be very useful in constraining the emissions projections

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Acknowledgement

- This work was performed on behalf of Northeast Texas Air Care, with support from the Texas Commission on Environmental Quality